Low Emissions Development as instrument against poverty and climate change

A case study on the electricity sector of Ghana

Matthijs van Poederooijen
Social and Political Sciences of the Environment
Faculty of Management
Radboud University Nijmegen
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Colophon:

Name:	Matthijs van Poederooijen
Post-Graduate Course:	Social and Political Sciences of the Environment
Faculty:	Faculty of Management
University:	Radboud University Nijmegen
Name of supervisor RU Nijmegen:	Drs. Jacques Klaver
Name of supervisor Ministry of Foreign Affairs:	Ir. Jan Cloin
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Ministerie van Buitenlandse Zaken

Radboud Universiteit Nijmegen

Photo on cover: The Akosombo Power Plant, the largest electricity generating plant of Ghana (VRA, 2007).

“*None of the Millennium Development Goals (MDGs) can be met without major improvement in the quality and quantity of energy services in developing countries*” (UNDP, 2010, p.1).

“Anthropogenic warming could lead to some impacts that are abrupt or irreversible, depending upon the rate and magnitude of the climate change” (IPCC, 2007a, p.53).

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Preface

This thesis combines two fields of study, namely development studies and environmental political science. This is no coincidence. My bachelor and master both encompass these studies and this is where my main interest lies. To combine these two elements into one thesis has been very rewarding. I believe that a lot of time both policy and science do not interconnect these two fields enough, while a whole lot of challenges, but also opportunities lie on the intersection of these subjects.

The thesis aims to provide insight into a new subject called Low Emissions Development. Because this is such a new term some difficulties came on my way when trying to define and comprehend this subject. This challenge has put me to the test and I feel that I have been able to show a lot of my academic knowledge and skills while doing this. Therefore doing research and writing this thesis has been a rewarding experience.

My internship at the Ministry of Foreign Affairs has provided a great opportunity to investigate this subject and to experience the field of subject hands on during my field trip to Ghana. This has offered understandings and insights into the political field of a developing country like Ghana and has been very worthwhile. Apart from the research the experience to do an internship at the Ministry of Foreign Affairs has also been very valuable to gain know-how on the way this governmental body works and to become inspired while following the standard state of affairs at the Ministry.

This research on Low Emissions Development and its potential in the electricity sector of Ghana took place within the framework of the Master of Science in Social and Political Sciences of the Environment from the Radboud University Nijmegen. It has been executed between the beginning of March 2010 and the end of July 2010. During these months, time has been committed to do research and to report the findings of this research in this thesis.

The study has been part of a research internship which took place at the Ministry of Foreign Affairs of the Netherlands. Within this ministry I have executed my internship within the Department of Environment, Water, Climate and Energy (DME) which operates between the Directorate General for European Cooperation (DGES) and the Directorate General for International Cooperation (DGIS). During this research I have been mentored by Jan Cloin at the Ministry of Foreign Affairs of The Netherlands and Sean Doolan at the Dutch Embassy in Accra. Jacques Klaver from the Radboud University Nijmegen supervised the writing of this thesis.

Acknowledgements

During this research I have been helped out by a lot of different people, not in the least place by the respondents. Hereby I would like to thank them for their time and effort for this. A few people I would like to thank specially. First of all Kitty van der Heijen and Tineke Roholl for giving me the opportunity to execute this research and to go to Ghana to collect data and information. From the Dutch Embassy in Accra my special thanks go Michiel Bierkens, Sean Doolan, Ruud van der Helm and Ton van der Zon. Last but not least I am very grateful for the support of my supervisors Jacques Klaver from the Radboud University and Jan Cloin from the Ministry of Foreign affairs for guiding me through my internship and providing essential support during my research.

Matthijs van Poederooijen
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Summary

Poverty and climate change are two of the biggest challenges for humankind in the twenty-first century. Developing countries suffer by far the most of these two problems. One way to deal with these problems is via so called *Low Emissions Development* (LED). This is a policy instrument which can assist developing countries to set a LED strategy for both development and climate change mitigation actions. Therefore LED is both a policy instrument and a policy strategy.

This thesis looks into LED and finds out whether the Dutch government can use this instrument to support the electricity sector of Ghana. The first part of this thesis deals with the question what Low Emissions Development actually means. One very important difference that has to be made is to separate whether one talks about LED for developed countries or LED for developing countries, because the goals of these two kinds of LED are very different.

There are *five main elements* of a LED strategy that can be distinguished: (1) long and short term vision, 2) analyses of greenhouse gas emissions and a reference of a global target, (3) assessment of the additional technology, capacity and costs, (4) National Appropriate Mitigation Actions (NAMA) & National Actions Plans on Climate Change and (5) monitoring of the results. All these five elements need be part of a LED strategy in order to ensure that it is successful.

The second element, a reference to a global target, is very important to ensure that mitigation actions within a LED strategy will contribute to the goal of keeping earth temperature increase below two degrees Celsius. This thesis focuses on this target and sets *criteria for both development* (relative strong economic growth) *and low emissions* (a target in 2050 which is the first step towards long-term stabilisation of carbon dioxide concentration). With these criteria it can also be determined whether a country has followed a LED path in the past or will follow one in the near future.

This thesis focuses on the electricity sector of Ghana and describes whether this sector will follow such a sustainable LED path in the near future. It is shown that with a business as usual scenario the electricity sector of Ghana will not follow such LED path. However the degree of deviation depends on the question whether Ghana will use natural gas in the near future to power its thermal plants or if it will keep using light crude oil. The West African Gas Pipeline, which transports natural gas from Nigeria to Ghana, has just been finished and the thermal plants are being retrofitted in order to also use this natural gas to generate electricity.

Next to this *fuel switching* three other actions described within the NAMAs of Ghana are also analysed. It leads to the conclusion that, of these three actions, the switch to natural gas is economically the most viable and will also reduce emission to the highest extent. Secondly, increasing the *share of renewable energy* will also reduce emissions substantially, but this option is very costly and therefore this can put pressure on other development targets of Ghana.

One of the points of discussion in this thesis is the *extension of mini-grids*. These can be rewarding from both a development and a climate change point of view, but the problem in Ghana is that people are not interested in these mini-grids, because they rather want to be connected to the main grid. Therefore it may be wiser to invest in mini-grids in other sub Saharan countries where electrification rates are lower and the rural areas further located from the electricity grid. In that way the economic viability of these mini-grids will also be higher.

Finally the conclusions provide *four recommendations* for the Dutch government. These recommendations are (1) to ensure that all five elements of LED are present when investing in these programmes, (2) to create a policy framework which involves all relevant departments and layers of a government to pursue the goals together, (3) to stimulate all developing countries in formulating LED strategies and (4) to ensure to that the actions in the LED strategy are no business as usual.

List of figures and tables

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List of acronyms

ATK	Aviation Turbine Kerosene
BAU	Business as usual
BBC	British Broadcast Corporation
C_4H	Methane
CDIAC	Carbon Dioxide Information Analysis Centre
CEESD	Centre of Energy, Environment and Sustainable Development
CFC	Chlorofluorocarbon
CFL	Compact Fluorescent Lamps
CO_2	Carbon Dioxide
COP	Conference of Parties
CSIR	The Council of Scientific and Industrial Research
DAC	Development Assistance Committee
DFID	Department For International Development
DGES	Directorate General for European Cooperation
DGIS	Directorate General for International Cooperation
DIIS	Danish Institute for International Studies
DME	Department of Environment, Water, Climate and Energy
ECF	European Climate Foundation
ECG	Electricity Company of Ghana
ECN	Energy research Centre of the Netherlands
EPA	Environmental Protection Agency
EU	European Union
FOEI	Friends of the Earth International
GDP	Gross Domestic Product
GNI	Gross National Income
GRIDCO	Ghana Grid Company Limited
Gt	Gigatonnes
GWh	Gigawatt Hour
HD	Human Development
HDI	Human Development Index
HIC	High Income Country
IFC	International Finance Cooperation
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Producer
JICA	Japanese International Cooperation Agency
KITE	Kumasi Institute of Technology & Environment
KWh	Kilowatt Hour
LCD	Low Carbon Development
LCDS	Low Carbon Development Strategy
LDC	Least Developed Country
LED	Low Emissions Development
LEDS	Low Emissions Development Strategy

LIC	Low Income Country
LMIC	Lower Middle Income Country
LPG	Liquefied Petroleum Gas
MDG	Millennium Development Goals
MFA	Ministry of Foreign Affairs of The Netherlands
MoE	Ministry of Energy
MRP	Mines Reserve Plant
N_2O	Nitrous Oxide
NAMA	National Appropriate Mitigation Actions
NAPA	National Adaptation Programmes of Action
NDPC	National Development Planning Commission
NGO	Non Governmental Organisation
ODA	Official Development Assistance
OECD	Organisation for Economic Cooperation and Development
PEF	Private Enterprise Foundation
PIK	Potsdam Institute for Climate Impact Research
ppm	Parts Per Million
PPP	Purchasing Power Parity
PRSP	Poverty Reduction Strategy Paper
PwC	PricewaterhouseCoopers
RE	Renewable Energy
RFO	Residual Fuel Oil
SNEP	Strategic National Energy Plan Ghana
TAP	Technology Action Plan
TAPCO	Takoradi Power Company
TAQA	Abu Dhabi National Energy Company PJSC
TICO	Takoradi International Company
TNA	Technology Needs Assessment
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNSD	United Nations Statistics Division
UMIC	Upper Middle Income Country
USAID	United States Agency for International Development Ghana
VALCO	Volta Aluminium Company
VRA	Volta River Authority
VROM	Ministry of Housing, Spatial Planning and the Environment of The Netherlands
WAGP	West Africa Gas Pipeline
WB	World Bank
WBGU	German Advisory Council on Global Change *[Wissenschaftliche Beirat der Bundesregierung Globale Umweltveränderungen]*
WRR	Scientific Council for Government Policy *[Wetenschappelijk Raad voor Regeringsbeleid]*
WWF	World Wildlife Fund

1 Introduction

Poverty and climate change are two of the biggest challenges for humankind in the twenty-first century. Developing countries suffer by far the most of these two problems. In 2008 a quarter of humankind still lives under the poverty line of 1,25 US dollar a day. Every night about one billion people go to bed feeling hungry. One third of all the children in the world are undernourished. Approximately one billion people are unable to write their own name and about two billion people have no access to electricity (WRR, 2010).

Features linked to climate change also do not look very bright. Anthropogenic climate change is caused by the manmade emissions of greenhouse gasses which are the effect of the burning of fossil fuels to generate energy and changes in land use. The Intergovernmental Panel on Climate Change (IPCC) estimated that 80% of the world's greenhouse gas emissions are due to the burning and combustion of fossil fuels (IPCC, 2007a). According to Nicolas Stern these manmade emissions of greenhouse gasses which cause the anthropogenic climate change "represent the greatest market failure that the world has ever seen" (Stern, 2008, p. 1). The IPCC (2007a) states that in Africa by 2020 between 75 and 220 million people are projected to be exposed to increased water stress due to climate change. In some African countries yield from rain-fed agriculture could reduce with 50%. In Asia the availability of fresh water is projected to decrease while endemic morbidity and mortality due to diarrhoeal disease primarily associated with floods and droughts are expected to rise in East, South and South-East Asia due to projected changes in the hydrological cycle (IPCC, 2007a). The developing countries in these continents are not or very little responsible for this enhanced climate change. This is a paradox of anthropogenic climate change. It is caused by rich nations, while the poor nations suffer the most from its consequences (Mendelson, Dinar & Williams, 2006).

The context sketched above shows the importance to battle both these challenges. Renewable energy has great potential to be a big part of the solution for both of these problems. Renewable energy can lift people out of poverty, because "energy services have an effect on productivity, health, education, safe drinking water and means of communication" (Gaye, 2007, p. 2). At the same time renewable energy reduces (the chance of) more manmade emissions from greenhouse gasses which cause anthropogenic global warming. Next to that are sustainable investments in energy systems in developing countries important to improve the quality and quantity of the energy sector. The United Nations Development Program calls these improvements in the energy sector of developing countries essential if we want to meet the Millennium Development Goals (MDGs) by 2015.

This is not an easy task. The main difficulty with renewable energy is that most of the time it is still more expensive than the conventional ways of energy production. This causes difficulties, because the capital means of developing countries are limited and in most cases development itself is more important in the short run. However the environmental sustainability argument of renewable energy might work, because in the long run the absence of environmental sustainable energy resources can slow down, stop or even reverse any swift and vast development. Depletion of unsustainable energy resources and the effects of climate change can both be the cause of this decrease in growth of development.

This is the rationale behind the investments in *Low Emissions Development* (LED) made by the Dutch government in developing countries (LED is also known as Low Carbon Development, this difference will be elaborated later on). This means that a country is capable of developing itself successfully, while producing fewer emissions of greenhouse gasses than business as usual. A main

argument for this path is that it is not necessary for developing countries to use the same kind of energy infrastructure as the developed countries to generate economic growth (MFA, 2008). LED can also bridge the gap between development policy and climate policy. The Dutch government states that the creation of *Low Emissions Development Strategies* can "be perceived as part of the Dutch climate diplomacy as well as a contribution to achieve the Millennium Development Goals" (MFA, 2010a).

However at this moment there is no broad consensus what this Low Emissions Development actually means. This new concept was first mentioned by the European Union in February 2007, when it was stated that developing countries needed assistance to follow low emissions development paths (EU Presidency, 2007). Since then no clear definition has been set up what Low Emissions Development comprehends. Questions which can be asked about LED are what kind of implications does LED create both for poverty reduction and energy policy, how the energy sector in a developing country will be affected by a LED strategy and how investments by international donors can make an effective contribution to LED. These are questions which this thesis will try to answer.

1.1. Social relevance

As stated above poverty and climate change are two of the biggest challenges that face human kind in the 21st century. Low Emissions Development is a policy framework which covers both of these challenges. That developing countries will play an important role in the face of climate change is shown by table 1 from the British Parliamentary Office of Science and Technology (Post, 2002).

	1990	2050
OECD countries	4,2	5,6
Developing countries	3,1	11,8

Table 1.1: Projection of the energy demand in 1990 and 2050 (in equivalents of gt. oil)

This table shows that countries of the Organisation of Economic Cooperation and Development (OECD) will use about 33% more energy between 1990 and 2050. In 1990 these developed countries still accounted for more than 57% of the world energy consumption. The developing countries on the other hand will increase their energy usage by more than three times between 1990 and 2050. Because of this, the total part of energy used by developing countries will decrease to 32%. This means that where in 1990 the developed countries still used more than half of the worldwide energy consumption, in 2050 the developing countries will use more than two thirds of the worldwide energy consumption.

Since the burnings of fossil fuels to produce energy accounts for 80% of the world's greenhouse gas emissions (IPCC, 2007a), this increase in energy consumption by developing countries will have a huge effect on climate change. This shows the importance of Low Emissions Development for developing countries. If the energy mix of developing countries would be the same in 2050 as the energy mix of developed countries today, the amount of greenhouse gas emissions will increase significantly, with all its consequences at hand. Therefore Low Emissions Development can be an important policy measure to reduce projected greenhouse gas emission of developing countries, while at the same time it maintains a clear development goal for these countries.

Next to that the terms Low Emissions Development and Low Carbon Development (LCD) have been new instruments during the Conference of Parties (COP) 15 in Copenhagen in December 2009. For example, the Danish Institute for International Studies (DIIS) issued a few days before the start of the conference a report how LCD can reduce poverty (Funder *et al*, 2009). Another study, from

PricewaterhouseCoopers (PwC, 2009a), introduces in December 2009 a Low Carbon Economy Index to measure the amount of emission different countries have to oblige to in order to keep the average world temperature increase below two degrees Celsius. Next to that, Low Carbon Development Strategies have also been proposed to the UNFCCC as part of a post-2012 international climate agreement (UNFCCC, 2009a). Most important of all, in the final Copenhagen Accord it is stated that "a low-emission development strategy is indispensable to sustainable development" (UNFCCC, 2009b, p.2).

This increasing use of the terms LED and LCD as an instrument in international climate negations also shows the social relevance to do research into Low Carbon Development. These ongoing climate negotiations will have an impact on how we live and the environment we live in for the next few decades.

1.2. Scientific relevance

Next to the social relevance mentioned above this thesis also has scientific relevance. At this moment of writing there is no scientific literature on Low Emissions Development. The reason for this is that LED is a very new concept, which has began floating around significantly since the COP 15 in Copenhagen in December last year. However there are articles from different institutions like the World Bank and the United Nations Development Programme (UNDP) which work with the term Low Carbon Development (World Bank, 2009a; UNDP, 2009a). The UNDP provides a handbook for countries to develop a Low Emissions Development Strategy. The World Bank provides a study from six emerging economies which have been doing research to assess their development goals in conjunction with greenhouse gas mitigation opportunities.

As mentioned before international institutions like DIIS (2009) and PwC (2009a) provide manifestos to use LED within the international climate negotiations and to make it part of a post-2012 international climate agreement. The same holds for Ockwell *et al*. (2009), who among other things look into the possibility to reduce poverty through low carbon development. The United Nations Environmental Programme (UNEP) launched a Climate Competiveness Index in 2010 to measure what national progress has been made on a low carbon economy (UNEP, 2010). Next to that Ellis *et al*. (2009) and Kim *et al*. (2009) provide papers within the OECD which can aid negotiations about LED. All these papers show that LED is becoming a common concept, but also a policy instrument which lacks the scientific support to make a clear definition what LED really means. There is also a shortage of scientific literature which looks at the possibility for LED to make progress on both Low Emissions and Development. This thesis aims to fill in parts of both of these missing elements.

1.3. Problem context

The problem context is to look at what way Low Emissions Development can give support to both development and climate change mitigation and in what way the Dutch government can efficiently support this sector in developing countries. For this research Ghana has been chosen as a case study. This country has been chosen as case study, because it complies with certain criteria. These are: (1) there are agreements between the government of Ghana and the Ministry of Housing, Spatial Planning and the Environment of The Netherlands of The Netherlands (VROM) to conduct research into LED, (2) Ghana is a partner country of the Ministry of Foreign Affairs of the Netherlands, (3) Ghana has a relative developed infrastructure and (4) there is awareness about LED in Ghana.

Next to that Ghana is also an interesting country because it is one of the biggest receivers of general budgetary assistance. Although no part of this actually goes immediately to renewable energy or Low Emissions Development at this moment, it is does bring an extra dimension in the problem context which can be interesting. It is not unthinkable that because of this budgetary assistance, the Dutch government might consider to also support other sectors like the renewable energy sector.

Within Ghana this research will focus solely on the electricity sector. This sector has been chosen, because at this moment there is relatively abundant data available about the electricity sector, in terms of electricity demand, electricity capacity, the electricity mix and the impact of a LED strategy. Therefore this sector is very well suitable for research and also makes it possible to operationalize the term Low Emissions Development within this thesis. Because of this it makes it possible to find out what contributions LED can have to both development and climate change mitigation. At this moment little is known about this contribution and about any criteria for Low Emissions Development. This thesis will focus on this gap and also look at possibilities for international donors like the Dutch government to support this LED in a developing country like Ghana.

1.4. Research purpose

Therefore the main purpose of this research is to analyse LED and give recommendations to the Dutch government in what way LED can be supported. If this support is effective it can give assistance in making the electricity sector of developing countries more sustainable. The Dutch government has embraced LED last year in its policy on environment and renewable energy in development cooperation (MFA, 2010b). Therefore this research also provides a basis for evaluation of the Dutch policy on international cooperation, because this thesis will also provide some insight into the kind of things which have to be taken into account when focussing on LED.

Next to these recommendations this research also has the purpose of filling a part of the knowledge gap on LED. As was written above, there is very little scientific literature so far on this policy strategy. A part of this research will focus on a standard which could be used to measure the amount of Low Emissions Development within a certain time frame. Another part of this thesis will fill a part of the knowledge gap on the possible efficiency of LED to increase both poverty and climate change mitigation.

1.5. Research questions

The central and main question of this thesis focuses on Low Emissions Development in the electricity sector of Ghana. This main question is; *what is the possible contribution of The Netherlands to a Low Emissions Development Strategy in the electricity sector of Ghana?* A few different sub questions have been deducted from this main question. These sub questions are:

1. *What does Low Emissions Development comprehend?*
2. *Which dimensions from the policy arrangement approach are crucial to influence the growth of prosperity in Ghana and of the carbon emissions in the electricity sector of Ghana?*
3. *What is the potential impact of Low Emissions Development on reductions of both poverty and carbon emissions in the electricity sector of Ghana?*
4. *What are the opportunities for Dutch support to the electricity sector of Ghana via a Low Emissions Development approach?*

The first sub question focuses on what LED actually means, where it comes from and whether any criteria can be maintained to find out whether a country is following a *Low Emissions Development Strategy*. The second question focuses on the electricity sector of Ghana and looks which main actors and factors influence poverty reduction and carbon emissions in Ghana. The third question focuses on the impact of LED. Both poverty reduction and reduction in carbon emissions due to LED policy will be looked at via this question. The last question focuses on the opportunities for the Dutch government to support the electricity sector of Ghana via a LED approach. All these questions combined will give an answer to the main question in the conclusion of this thesis.

1.6. Philosophy of science

An important part of doing research is the philosophy of science which is being used. Guba and Lincoln (1994) state that different philosophies of science will have significant implications on the practical level of a research. The philosophy of science which will be used for this thesis is difficult to capture in one specific scientific philosophy like positivism or constructionism. By looking at the possible contribution of The Netherlands to support a Low Emissions Development strategy in the electricity sector of Ghana this thesis involves the role of stakeholders. This implies social-constructionism, because there is an emphasis on the social source of meaning (Crotty, 1998). There is not one truth, but many truths consist together next to each other. This social-constructionism is also the main philosophy of science of this thesis.

On the other hand in chapter four this thesis sets different criteria for Low Emissions Development. These criteria are based on hard numbers and the calculations have a mathematical structure. This kind of research has a post-positivist character, because the research of this conceptual model is an attempt to find the truth as a justified belief (Goldman, 1979). Taken together this post-positivism is used for a certain part of this study. Elements from both fields, social-constructionism and post-positivism, are represented in the next chapters.

2 Methods of research

This chapter deals with the methods of research which have been used during this study. First it will look at the research framework which has been used for this thesis. Secondly this chapter will go into the literature research. Thirdly the methods which have been used to define criteria for a Low Emissions Development Strategy will be looked upon. Fourthly the methods used to collect data about the electricity sector of Ghana will be explained. Then this chapter will go into the methods of gathering data during qualitative interviews in Ghana. Last but not least the limitations of these research methods in this thesis will be shown.

2.1. Chapter outline

Figure 2.1 shows the chapter outline for this thesis. Chapter one is not included in this figure, because it comprehends the introduction. The second chapter encompasses the methods of research which are highlighted by the boxes 'qualitative interviews in Accra' and 'literature research' in figure 2.1. Chapter three focuses on the theoretical framework for this thesis (the policy arrangement approach) and the figure shows how this chapter supports chapter five and seven in this thesis.

Preliminary research, literature on LED and interviews with experts led to the step to define Low Emissions Development. Defining LED shows that this new concept needs certain criteria in order to use it in practise (chapter four). After this the mapping of the electricity sector of Ghana stood central, which was done with help from the information from the qualitative interviews and the theory of the policy arrangement approach (chapter five). With the mapping of the electricity sector, it becomes possible to measure the impact of a Low Emissions Development Strategy, again with the help from the qualitative interviews (chapter six). This leads to the chapter about discussions over LED and the possibility to look at potential support from the Dutch government (chapter seven). Finally this all leads to conclusions and recommendations which can be found in the last chapter (chapter eight).

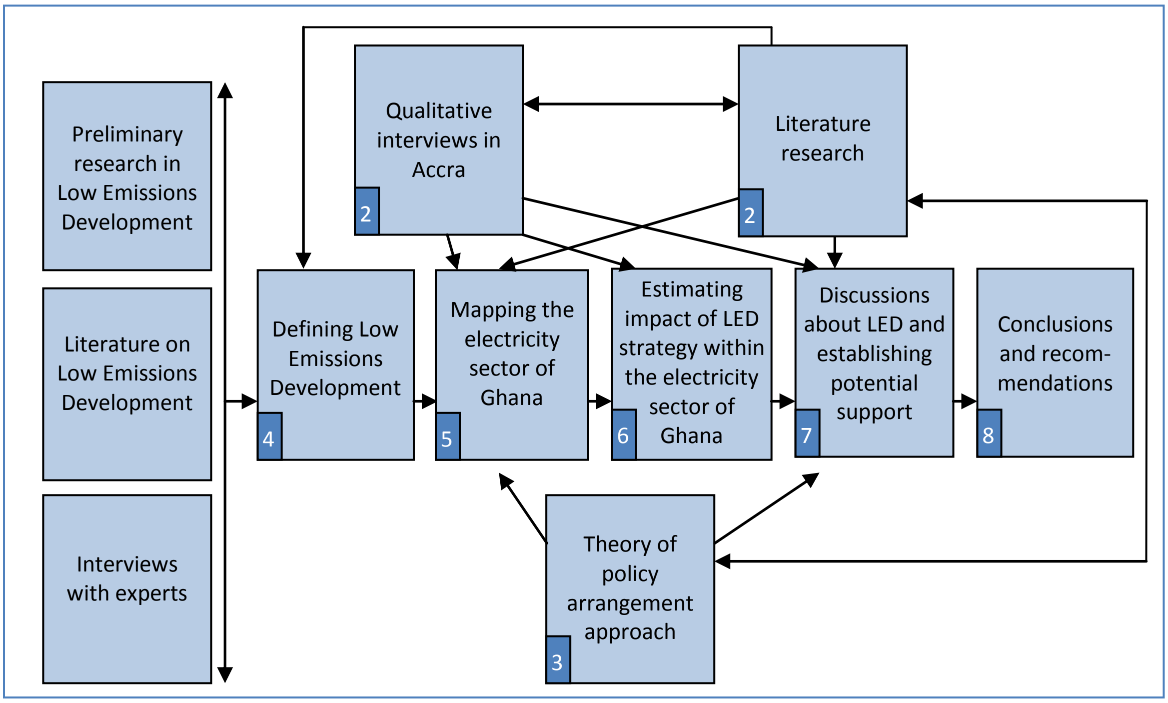


Figure 2.1: Chapter outline Low Emissions Development

All these different parts of the research have been worked out by operationalizing the sub questions. This was done by coming up with different indicators for all the sub questions of the different chapters and finding ways to gather the needed information for those indicators. This information was found either in literature, by comparing data sheets from different institutions or during qualitative interviews. Together all this information will be used to answer the main question of this thesis: *what is the possible contribution of The Netherlands to a Low Emissions Development Strategy in the electricity sector of Ghana?*

2.2. Literature research

As mentioned before there is little scientific literature on Low Emissions Development. However a few institutions have been using the term in the last two years more frequently within different contexts. Therefore there is still quite some literature at hand about LED which has been used in this thesis in order to understand this concept entirely. Whether it has to do with finding out who propelled this concept into international negotiations (Project Catalyst, 2009a), how it is used at this moment in different countries (World Bank, 2009a; UNEP, 2010), when it was adopted by governmental institutions (EU Presidency, 2007) or how it can be used during negotiations (Ellis *et al*, 2009; Kim *et al*, 2009), the literature at hand about LED gives some vital information about the concept itself.

Next to literature about LED there is also a lot of other literature which provided important background information for this thesis. For instance literature about Ghana and the electricity sector (Energy Commission Ghana, 2006; Gboney, 2008; Brew-Hammond & Kemausuor, 2009), literature about climate policies in developing countries (Neuhoff, 2009; Kok *et al*, 2008; Prins *et al*, 2010) and of course also literature about the policy arrangement approach (Liefferink, 2006; De Boer, Kuindersma, Van Der Zouwen & Van Tatenhove, 2008). All this literature has played an important role in providing background information for different topics of this thesis.

2.3. Criteria for LED

In chapter four work has been done on criteria for a LED Path. This model has been made by collecting data from the United Nations Statistics Division (UNSD) about Gross National Income (GNI) (or Gross Domestic Product (GDP) as it was formerly known) per capita in Purchasing Power Parity (PPP) and data about the amount of Carbon Dioxide (CO_2) emissions per capita of different countries. These data has been processed via Microsoft Excel to make graphs of the Low Emissions Development Paths of different countries. The trend in these graphs can be compared to the proposed trend of different countries to keep the worldwide average temperature rise below two degrees Celsius. The calculation for these proposed trends for different groups of countries is explained in paragraph 4.6. The comparison between the real track and the proposed track provides a tool to define whether a country or a certain sector within a country is on the right track in following a Low Emissions Development Path.

2.4. Data electricity sector Ghana

An important part of this research was to gather information about the electricity sector of Ghana. A lot of information about this sector is not very easily available and like a staff member from an embassy in Accra warned; “a lot of information and data about Ghana only exist on a hard copy, on a single notebook or in people’s head” (personal communication, 05/2010). Therefore gathering the right numbers and information proved to be a bit of a challenge.

A number of statistical data and reports are available on the website of the Energy Commission of Ghana, like Energy Statistics between 1990 and 2006, a Strategic National Energy Plan (SNEP) and demand projections for electricity until 2020. Other data and data sheets have been collected during quantitative interviews. From the Energy Foundation, the Volta River Authority (VRA), the Ministry of Energy, the Environmental Protection Agency, the Ghana Chamber of Mines and the Energy Commission different types of data were asked during the interview. In almost all of these cases it was possible to gather certain types of documents which provided a lot of these data, for instance (1) Ghana Energy Policy Working paper, (2) Evaluation of a Rural Electrification programme in the Western Region of Ghana, (3) Report on the power supply in Ghana, (4) Reports on Energy Efficiency Programmes, (5) different laws which apply to the electricity sector and (6) the 2010 Energy Outlook for Ghana.

The information from these different types of reports and datasheets provided me also with a tool to double check the facts and figures which were mentioned during the quantitative interviews and vice versa. Also different literature sources, mainly the work of William Gboney (2008), provided opportunities to double check information and to process this information via triangulation.

2.5. Qualitative interviews in Ghana

As noted before a lot of information was gathered via qualitative interviews in Accra. These interviews took place between the 2nd of May and the 24th of May 2010. The Dutch Embassy in Accra provided the working space to organise and conduct these interviews. Different staff members from the Embassy and the Ministry of Foreign Affairs of the Netherlands provided contacts within the electricity sector, the climate sector and from Non Governmental Organisations (NGO) to interview. These persons have been contacted via telephone or e-mail to ask if they wanted to participate in an interview for this research. Some of the participants were also sent a letter with additional information about the research when asked. Via snowball sampling during the first interviews other stakeholders within the electricity sector where identified and invited for an interview.

This resulted in a total of twenty interviews within the three weeks research period in Accra. The names of the different interviewees can be found in *annex 1*. For almost all of these 20 interviews a specific semi-structured interview guide had been prepared beforehand. *Annex 2* shows an example of such interview guide. These semi-structured interview guides were formed by looking at the different indicators from the operationalisation process and combining these to the different interviews. During 14 of the 20 interviews it was possible to tape the interviews on a memo recorder. The reason the other 6 interviews were not recorded had either to do with technical failure, logistic constraints (it is not allowed to carry any electronic devices into the American Embassy), or because it was simply not allowed by the interviewee.

During these interviews notes have been taken which have been worked out on a computer afterwards. Via this method 20 different (meeting) minutes have been worked out. In parts where information was missing or where important things were said, those recorded interviews present have been used as backup to listen to parts of the conversation again. The minutes of all the interviews have been used as basic information for different parts of the thesis (mostly chapter four, five, six and seven), like understanding the opinion different interviewees have about LED and climate politics and to double check other information from other sources[1].

[1] When information from these interviews has been used in this thesis it is referred to as personal communication. No names have been included, because of confidential reasons.

2.6. Limitation to the research methodology

All the different research methods mentioned above have some limitations. In this paragraph a few of these limitations are mentioned. These apply to the literature research, the criteria which have been set up to measure LED paths, the selection procedure of the interviewees, the problem of missing data and the time constraint for both data collection and analysis.

First of all, there is only a certain amount of literature available about LED. This makes it not only difficult to embrace the concept itself, but because it is so new it also means that a lot of information and processes around this concept are not yet written down. This makes is difficult to have any certainty that literature research provides enough information about the concept LED and its latest developments. This limitation can be dealt with by verifying with other sources what the latest developments are in LED. This has been carried out to a certain extent during different conversations with staff members from the Energy research Centre of the Netherlands (ECN) and the staff members from the Ministry of Foreign Affairs.

Secondly, the tool to define a Low Emissions Development path, which is being put apart in chapter four, is very broad. The classifications for the different groups of countries are Low Income Country (LIC), Lower Middle Income Country (LMIC), Upper Middle Income Country (UMIC) and High Income Country (HIC). This classification has been based on the World Bank Atlas Method (World Bank, 2010) and the method looks at the Gross National Income of the different countries. This means that the different contexts of countries have not been taken into account in detail, for instance whether they are resource intensive countries or not. The report of PricewaterhouseCoopers about the Low Carbon Economy index does make this distinction (PwC, 2009a). See box 5.1 for a more detailed analysis of the limitations of this tool.

Thirdly there are some limitations concerning the quantitative research method. For instance the participants have been chosen mostly via snowball sampling. This means that participants have not been chosen via random sampling and this introduces bias in the research method ('t Hart *et al.*, 2005). Because of the nature of this research, which has to do with a new concept like Low Emissions Development and specific issues within the electricity sector of Ghana, this does not have to be a big issue. However, there is a chance that the response to certain questions is biased, because of the non random sampling method of participants.

Another reason why the research method can be biased is because the group of participants is not too big. This does not have to be a very big issue concerning the nature of the research, which has an inductive character. This means that this research is not testing a Low Emissions Development theory via a big survey, but the purpose of this research is to understand what Low Emissions Development actually means by consulting different sources. However, again when opinions of Ghanaians are asked, it can mean that the results are biased, because only a part of the twenty participants have been questioned about their opinion. Therefore the reference group is very small. This limitation can be dealt with by taking into account and making it very clear when any conclusions or remarks about these opinions are written down.

A fifth limitation of the research is missing data. This has to do with a part of the nature of the research subject, which are the greenhouse gas emissions in the Ghanaian electricity sector. To give an example about this limitation, the biggest generation utility in Ghana does not keep track of any carbon emissions of their own power plants (personal communication, May 2010). This means that only estimations can be made by looking at the different kinds of thermal plants and the amount of light crude oil or gas they use. A way to deal with this limitation by gathering information about

emissions, load factors, fuel used and thermal efficiency of power plants from as many different sources as possible.

The last limitation of these research methods is time constraints. Limited time to conduct interviews in Ghana means that the analysis of the Low Emissions Development Path of the Ghanaian electricity sector is not very exhaustive. One example is that it was not possible to conduct an interview with the Public Utilities Regulatory Commission (PURC), which is in charge of the price of electricity in Ghana and the price of the feed in tariff which might be introduced by a new Renewable Energy bill. This limitation is part of the reason why the analysis of a possible Low Emissions Development Strategy of the electricity sector is not to too exhaustive.

3 Theoretical Framework

This chapter deals with the theoretical framework which is used in this thesis to provide an instrument for deeper analysis. The theory which is being used is the policy arrangement approach. Among others, this theory has been extensively used by Van Tatenhove *et al*. (2000) in their book *Political modernisation and the Environment: the renewal of environmental policy arrangements* and also by Duncan Liefferink (2006) in a book called *Institutional Dynamics in Environmental Governance*. The Wageningen Statutory Research Tasks Unit for Nature and the Environment also uses the theory in a report about the Dutch Ecological Networks (De Boer *et al*., 2008).

3.1. Policy arrangement approach

Policy arrangement can be defined as the temporary stabilisation of the content and organisation of a certain policy domain (Van Tatenhove *et al*. 2000). The policy arrangement approach tries to link changes in policy analytically to structural changes in our society. In this case policy relates to the LED policy within the Ghanaian electricity sector. The structural changes relate to the developments which lead to changes in this sector. A concrete example of these structural changes is the increasing focus on climate change by the international community within the last decade. Another example is the energy crisis which occurred in 2007/2008 in Ghana. Both events had significant influence on the policy within the Ghanaian electricity sector. The former example increases the chance of a LED focus within the electricity sector policy, because the extra attention to climate change by the international community for de last decade also causes more focus on climate change within Ghana. The other example, the energy crisis of 2007/2008 in Ghana, reduces that chance of a LED focus within the Ghanaian electricity sector, because the shortage of electricity in those years results in policy goals which do not focus on climate change.

In the policy arrangement theory, policy is seen as a kind of language. It is something which is common in everyday life and which everybody has to deal with. An important similarity between policy and language is that they both change slowly, it does not occur overnight (Liefferink, 2006). An important reason is that policy practices become 'institutionalized'. This means that under influence of ongoing interactions between different parties they will anchor in patterns, structures, routines and rules which on itself will influence the behaviour of the involved parties. This results in the fact that policy practices have a certain kind of stability (De Boer *et al*., 2008).

At the same time the policy arrangement approach supposes that policy practices are continuously being influenced by changing conceptions about policy problems and the solutions which can deal with these problems. These changing conceptions are among other caused by changing power relations between the actors involved and by the societal developments. The consequence of this is that policy practices undergo ongoing changes (De Boer *et al*., 2008). In this sense the energy mix of Ghana has been influenced by ongoing changes because of these different power relations and societal developments.

To understand the way these changes occur, the policy arrangement approach distinguishes four dimensions. These four dimensions are: *actors and coalitions, resources and power, rules of the game* and *discourses.* The dimensions can be placed in a tetrahedron, which links them together (figure 3.1, copied from Liefferink, 2006). The first three dimensions go into the organisational aspects of the policy arrangement. The discourse dimension focuses on the content of these aspects (Van Tatenhove, 2000). From this tetrahedron it can be deducted that there is a strong link between the

four dimensions. They are indissoluble connected and influence each other. Because of this, it is possible to describe how a difference in one of the dimensions can influence the other dimensions.

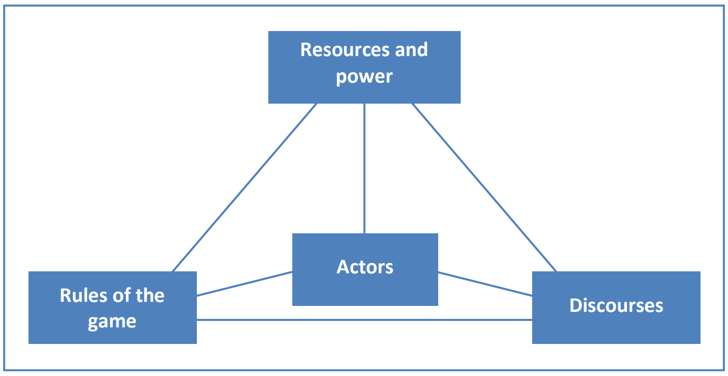


Figure 3.1: Tetrahedron of the four dimensions of the policy arrangement approach

3.2. Actors

Within the policy domain of the Ghanaian electricity sector a lot of different actors are involved. In this research actors are defined as organisations with a certain societal goal. This means that individual persons are not included as research topic within this thesis. Actors play an important role within the policy arrangement approach, because they materialise the other analytical categories (Liefferink, 2006). The different actors can achieve their policy goals by engaging in policy processes. Within these processes they can either support the dominant policy discourses or they can challenge the discourses (Arts & Van Tatenhove, 2004).

The actors within the policy arrangement approach can be mapped via the method which is introduced by Liefferink (2006) in figure 3.2:

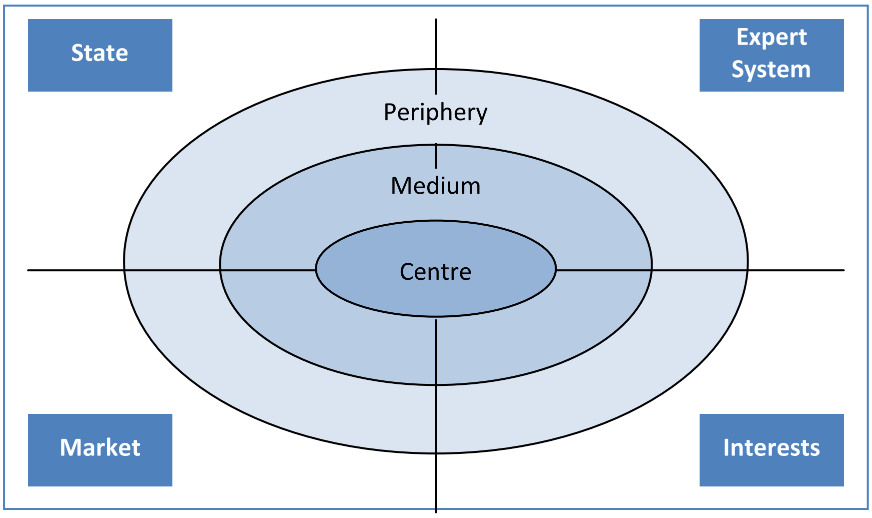


Figure 3.2: Mapping of actors within the policy arrangement approach

The mapping of the different actors makes it possible to differentiate the actors. First of all there are the actors which can be defined as governmental organisations (State). Secondly there are actors which are defined as knowledge institutes (Expert System). Thirdly there are organisations or businesses which represent the market (Market). Finally some organisations can be grouped as interest organisations, like NGOs or donors who have certain values which they represent (Interests).

Apart from that, a differentiation can also been made between actors that operate in the periphery of the policy domain, actors that operate in the centre of the policy domain and actors that operate between these two ends. In chapter five this mapping method will be used on the different actors within the Ghanaian electricity industry.

3.3. Resources and Power

The dimension 'resource and power' relates in this research to money, knowledge, political legitimacy and influence in the political policy. These resources can be used by the actors to help them to steer the policy process to a certain direction (De Boer *et al*., 2008). Therefore the allocation of resources determines the power relations of the different actors. This allocation can change over time, for instance because new actors or discourses enter the policy arrangement. To identify these power relations of the different actors it is important to link the dimension of actors and resources, because this will show in what way the different actors depend on each other for resources like money, information and political legitimacy (Liefferink, 2006).

In the policy game resources can have two different meanings. First of all resources can be seen as 'weapons'. This means that actors try to determine the different outcomes of the policy game by using the resources in their advantage. On the other hand resources can also be seen as 'prizes'. This means that the actor will try to improve their situation by changing the distribution of resources to their advantage (Liefferink, 2006). In that sense, recourses can be seen as both *input* for a policy arrangement, but also as the *output* of a policy arrangement.

3.4. Rules of the Game

The dimension 'rules of the game' within the policy arrangement approach refers to legislation and other regulatory measures which influence changing processes. Liefferink (2006) defines rules as the "mutually agreed formal procedures and informal routines of interaction within institutions" (Liefferink, 2006, p. 56). In that sense the rules have a strong commitment to the dimension of actors. Rules determine among others who is allowed to intervene and participate in the policy arrangement, how policy is made and implemented and who is responsible for the different policy tasks (De Boer *et al*., 2008).

In that sense rules define the interrelation between the different actors. They give guidance how actors should act properly and legitimately. They determine who is in and who is out of the game and how one can get into the game. Rules either have a formal or an informal nature. Formal rules have been approved by National Parliament or International Institutions like the United Nations (UN). Informal rules on the other hand are not written down but can come forward out of traditions, routines or customs (De Boer *et al*., 2008).

3.5. Discourses

Finally, the dimension discourses relate to the vision and ideology of the involved actors. Hajer defines discourse as "A specific ensemble of ideas, concepts, and categorizations that are produced, reproduced and transformed in a particular set of practices and through which meaning is given to physical and social realities" (Hajer, 1995, p. 44). In that sense discourses can be seen as interpretative schemes by which meaning is given to a policy domain (Arts & Van Tatenhove, 2004). In that case discourses can define the strategic positions of actors. Within one policy arrangement different discourses can either compete with each other or there can be one dominant discourse.

A distinction can be made between two different kinds of discourses. First of all there are *content related discourses*. These discourses apply to the content of a certain policy arrangement, for instance about the role mitigation actions should play within the policy of Low Income Countries. Secondly there are also *steering discourses*. These discourses relate to the way different actors should steer or should be steered within the context of the policy arrangement (De Boer, 2008). An example of this is the role the generation utility in Ghana should have in deciding what the electricity mix of Ghana should be within the next few decades. In this thesis focus solely will be put on the first kind of discourses, namely the content related discourses.

3.6. Policy arrangement approach and the Ghanaian electricity sector

The way this theory can be used for this research is to look at the way different dimensions mentioned above play a role in the electricity sector of Ghana. An example of this implementation is shown in figure 3.3. Here is a first draft of a possible way how the electricity sector of Ghana is formed.

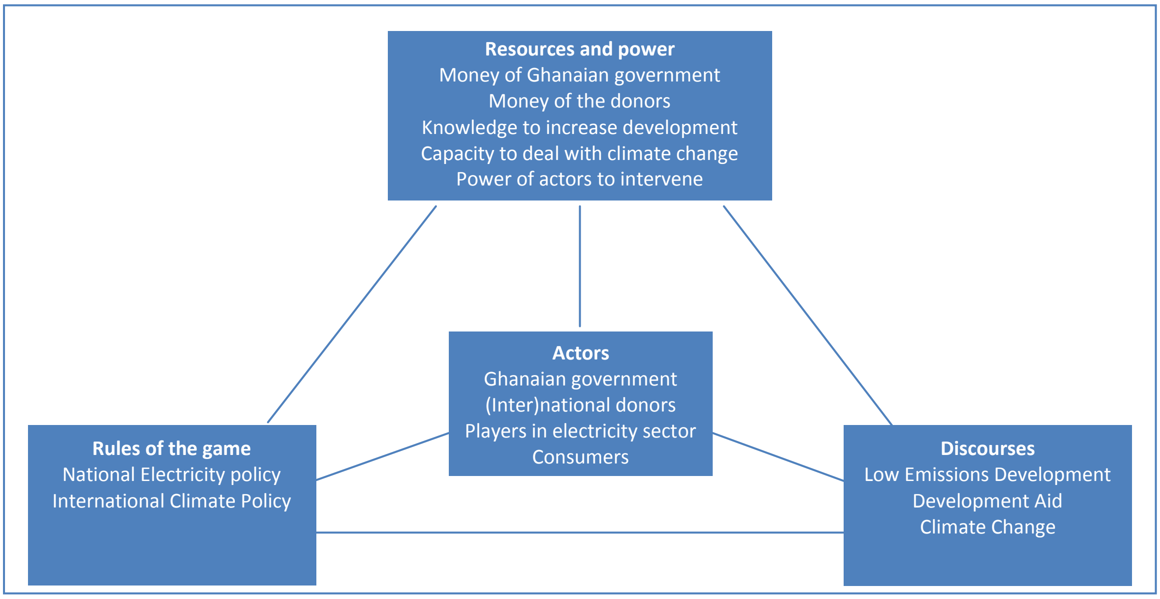


Figure 3.3: First draft tetrahedron of LED policy within the electricity sector of Ghana

This draft is a first design of what the electricity sector in Ghana looks like. The different dimensions will be further elaborated in chapter five, when the electricity sector of Ghana will be clarified. Then the different kinds of actors, rules of the games, resources and power and discourses will be filled in.

3.7. Other theories

Considerations have been made to use other theories next to or instead of the policy arrangement approach. The two main theories which could make a contribution to this thesis are the theory of transition management and the theory of ecological modernisation. This paragraph will describe what these theories encompass and why they not have been chosen in this thesis.

Transition Management

Rotmans *et al*. (2000) have introduced the concepts of transition and transition management as a new integrative approach in the field of sustainability and governance in order to deal with persistent problems. The transition framework offers analytical tools for structuring and explaining the

dynamics of social systems, such as the energy sector. Transition management attempts to influence, facilitate, stimulate and organize processes that contribute to the transition (Brugge & Rotmans, 2007).

This theory could be useful for LED, because a transition within the electricity sector is needed to ensure a LED path is being followed. However, this thesis describes the electricity sector of the developing country Ghana. In this case the development of the electricity sector itself will receive more focus than the transition of a persistent problem within that sector. Therefore this theory has not been used in this thesis.

Ecological modernisation

The main principle behind Ecological Modernisation is that economic growth and environmental crisis can reconcile within one policy. Within this framework nature is considered a public good rather than a free good and environment can be managed within a liberalised market where polluters can be made to pay the 'real costs' of their damage to the environment. "This will promote greater efficiency of production and the innovation of more environmentally friendly technology and 'green products', which can achieve premium prices and open up new market opportunities" (Amanor, 2009, p. 65).

This theory also seems promising in combination with LED, because it ensures that both environment and development can reconcile with each other. However, the theory of ecological modernisation contributes to the viewpoint that environmental challenges are not a crisis, but an opportunity. Hajer (1995) defines ecological modernisation, as "the discourse that recognizes the structural character of the environmental problematic but none the less assumes that existing political, economic, and social institutions can internalize the care for the environment" (Hajer, 1995, p. 25).

Therefore this theory is not well suited to contribute to this thesis, because it is not the aim of this thesis to understand how and why LED could enter the international arena. The aim of this thesis is (among other things) to look what LED means, to evaluate its surplus value and to give the Dutch government recommendations about LED within the electricity sector of Ghana. This electricity sector will be described in chapter five, but chapter four will first go into the question what LED exactly means.

4 Low Emissions Development

Adaptation to climate change in the policy of developing countries is getting more and more attention in the last few years. This might not be too surprising, because the consequences of climate change can influence the development rate of the developing countries. Kok *et al*. (2008) state that "development efforts will be seriously hampered by the risks of climate change if these are not tackled" (Kok *et* al., 2008, p. 104). Examples of the influence of climate change are reduced economic growth due to climate change damages, threats of under-performing investments and lower food production due to maladaptation to a changing climate. Kok *et al*. consider development that does not take climate change into account unsustainable, because it will create societies that are vulnerable to climate change.

However, since the negotiations about a new post-2012 protocol on climate change, there has also been increasing attention for mitigation actions of developing countries to combat climate change. To show a few examples: (1) In July 2008 Marthinus van Schalkwyk, the minister of environmental affairs and tourism of South Africa introduced the Long Term Mitigation Scenario Report for South Africa (Department of Environment Affairs and Tourism, 2008). Van Schalkwyk claimed that "while developed countries bear most of the responsibility for causing the problem to date, developing countries – including South Africa – must face up to our responsibility for the future" (Van Schalkwijk, 2008). (2) In May 2010 the Guyanese government introduced its third Low Carbon Development Strategy (LCDS). President Bharrat Jagdeo proclaimed that the Guyanese government "wanted to break the false debate which suggests that a nation must choose between national development and combating climate change" (Jagdeo, 2010). (3) During the 15th Conference of Parties (COP 15) in Copenhagen, the Ghanaian President John Evans Atta-Mills outlined Ghana's position on climate change. He proclaimed that "Ghana will pursue low carbon development growth path even though our emissions currently are very insignificant" (Attah-Mills, 2009, p. 1).

These examples show that mitigation actions by developing countries are getting more and more attention lately. One term that covers these different kinds of actions can be called Low Emissions Development (LED). This chapter will focus on this term and look where the term comes from, how it can be defined and which countries apply LED. Next to that this chapter will also look from which kind of elements LED exists and introduce a model to set criteria for LED. With these questions it will be possible to answer the first sub question of this thesis: *What does Low Emissions Development comprehend?*

4.1. History of LED

As described earlier, the term Low Emissions Development or an equivalent of it has been introduced in the international climate negotiations not too long ago. One of the first times when the term (or equivalent of the term) Low Emissions Development was mentioned by a government was when it was part of the presidency statement from the EU at the Sustainable Development/ Intergovernmental Prepatory Meeting on Climate Change the 26th of February 2007. Harrald Lossack from the Federal Republic of Germany and on behalf of the European Union stated that "it is important to develop long term predictable policy frameworks to help countries move towards a low carbon emission society" (EU Presidency, 2007).

After this in 2008 the ClimateWorks Foundation, a non profit philanthropic foundation headquartered in San Francisco, launched Project Catalyst in May 2008 to "provide analytical and

policy support for the United Nations Framework Convention on Climate Change (UNFCCC) negotiations on a post-Kyoto international climate agreement" (Project Catalyst, 2009a, p. 3). This encompassed the introduction of the first generation Low Carbon Growth Plans for both developed and developing countries in order to achieve a comprehensive transition to a low-carbon growth pathway. The ClimateWorks Foundation has been successful in lobbying for these low carbon growth plans.

4.2. The term Low Emissions Development

A lot of different meanings and synonyms on the term Low Emissions Development have been used by different countries and organisations to capture mitigation actions into one term. For instance the European Climate Foundation and the Climate Works Foundation use the term 'Low Carbon Growth Plan' to define these actions. The British government uses the term 'Low Carbon Roadmap' instead, while the organisation Friends of the Earth talks about 'Low Carbon Strategy'. The Guyanese government mention the term 'Low Carbon Development Plan' and members of the NGO community, like World Wildlife Fund (WWF) and Greenpeace call for a 'Zero Carbon Action Plan' during the COP 15 in Copenhagen. Finally, the United Nations and the European Union maintain the term 'Low Emissions Development Strategy' (LEDS).

In this thesis the term 'Low Emissions Development' (LED) has been chosen. The main reason is that both the European Union and the United Nations use the term 'Low Emissions Development' to refer to mitigation actions by developing countries. Next to that the term 'Low Emissions Development' is also used in the Copenhagen Accord (UNFCCC, 2009b).

Difference in focus

There are two things which are good to keep in mind when looking at LED. The first thing is to realize to what kind of country the term relates. In general a distinction can be made between mitigation actions of developing countries and mitigation actions of developed countries. This is because the word 'development' in the term 'Low Emissions Development Strategy' plays a very different role if the focus is on a developing country or developed country. In this thesis, development in developed countries implies an ongoing economic growth while switching from a high carbon intensive energy sector to a low carbon intensive energy sector. Development in developing countries implies a situation where strong economic growth is stimulated, while at the same time the energy sector is transformed from a high biomass intensive sector to a higher electrified intensive sector. Figure 4.1 shows the difference between these two focuses.

These differences are huge. For developing countries, a LED strategy will aim to decrease the biomass part, and increase the renewable energy part, increase the electricity access and increase the total usage of energy. For developed countries, a LED strategy will aim to increase the biomass part (although a different type of biomass) and the renewable energy part, to decrease the use of fossil fuels and to decrease the total usage of energy. The only similarity between these two focuses within the electricity mix seems to be the increase in renewable energy. All the other focuses within this mix are directly opposite or nonexistent in the other group of countries.

However, there are also other similarities, like a general focus on fuel switching and a focus on the increase of quality of life. Although this is the case in both types of countries the word 'development' can have a very different meaning. Within a developed country, the term Low Emissions Development can refer to the development of renewable energy sector itself. In a developing country, the term Low Emissions Development can refer to the human development of the

inhabitants of that country (energy access). In this thesis the focus will be on the last part, the development of the inhabitants of a developing country itself.

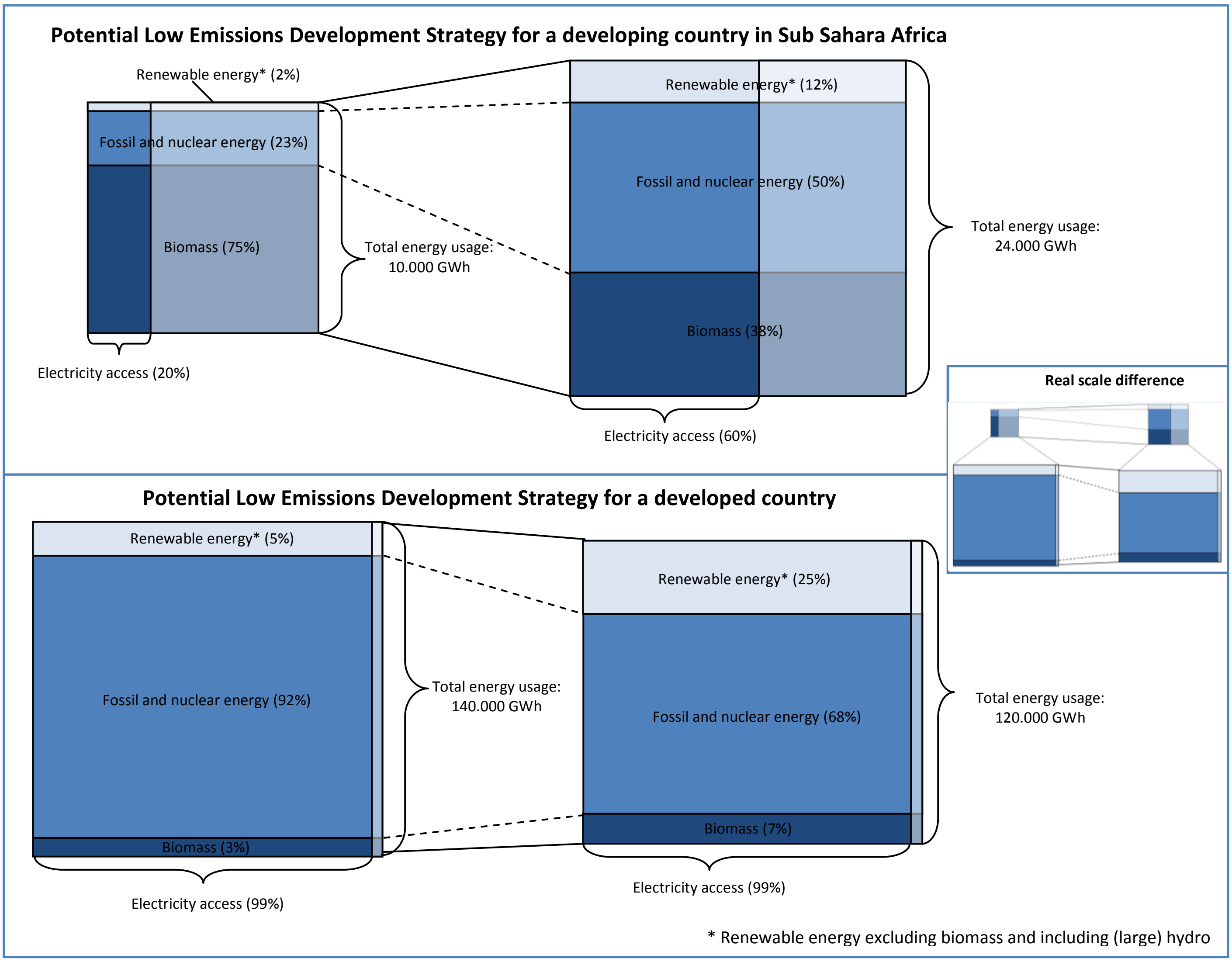


Figure 4.1: Difference LED path for developing and developed countries

Differences in meaning

The second thing which needs to be kept in mind when choosing a term for mitigation actions is what exactly is meant by the term 'Low Emissions'. This has two aspects. The first aspect is that the word 'low' refers to something else. It should be clear what this is. Does it refer to the amount of emissions in a business as usual scenario? Does is refer to the amount of emissions compared with other countries? Or does it refer to the amount of emissions which are low enough to keep the earth temperature increase below two degrees Celsius? The meaning of the word 'Low' therefore indicates an important reference point.

The second aspect which has to be kept in mind is to know what is meant exactly by the word 'emissions' in the term 'Low Emissions Development'. There are different kinds of gasses that contribute to anthropogenic global warming. Houghton (2005) explains that the increase in carbon dioxide (CO_2) has contributed for about 70% to enhanced global warming, methane (CH_4) contributed for about 24% and nitrous oxide (N_2O) for about 6% to anthropogenic global warming. Chlorofluorocarbon (CFC), other gasses and changes in ozone are ignored for the moment, because

they vary considerably over the globe and are more difficult to quantify. Next to that the greenhouse warming potential of one single methane molecule and one single nitrous oxide molecule within 100 years is relatively 25 times and 298 times stronger than CO_2 (IPCC, 2007b). This shows that it is important to know where the word 'emissions' refers to in a term like 'Low Emissions Development'. Does it refer only to CO_2 or also to CH_4 and N_2O? The kind of gasses which are targeted in policy will influence the effects on climate change.

However, it is important to realize that within the thesis the only greenhouse gas which is used in calculations and criteria settings is the greenhouse gas carbon dioxide (CO_2). This limitation is caused by restrictions in time and limited data and because of the focus on electricity generation.

4.3. Definitions

In the first chapter of this thesis the term Low Emissions Development was explained as a term which means "a country is capable to develop itself successfully, but with fewer emissions of greenhouse gasses than business as usual". This paragraph will go into this definition and clarify the different words which are used within the definition.

Human Development

The first part of this definition is about the development of a country. This development refers to the *human development* of the citizens of that country. Human development is defined by the UNDP in their groundbreaking Human Development Report of 1990 as follows:

> "Human development is a process of enlarging people's choices. In principle, these choices can be infinite and change over time. But at all levels of development, the three essential ones are for people to lead a long and healthy life, to acquire knowledge and to have access to resources needed for a decent standard of living. If these essential choices are not available, many other opportunities remain inaccessible." (UNDP, 1990, p.10)

Income can be an important means to enlarge these choices. Income can be measured by looking at the Gross National Income (GNI) per capita of a country. An increase in this Gross National Income can be defined as economic growth. However, the UNDP warns that more income, which leads to this economic growth, is not the sum total of human life (UNDP, 1990). This idea is not original and goes back to Aristotle when he claimed more than two thousand years ago in his book *Nicomachean Ethics* that "wealth is evidently not the good we are seeking; for it is merely useful and for the sake of something else" (Aristotle, *in*: Ross, 1980, p. 7). Therefore income does not seem the best indicator to measure human development. The Human Development Index (HDI) from the UNDP, which also looks at indicators like illiteracy rate, life expectancy, enrolment ratio in education, long-term unemployment and a gender related development index seems a more profound indicator of human development (UNDP, 2009b). The improvement of these indicators is also an important goal within the Millennium Development Goals (MDGs) of the United Nations, which 192 have agreed to achieve by 2015 and include reducing extreme poverty, reduce child mortality rates, fighting disease epidemics and developing a global partnership for development.

On the other hand Gustav Ranis recognizes that "increased incomes will increase the range of choices and capabilities enjoyed by households and government". This means that "economic growth will enhance human development" (Ranis, 2004, p.3). Sudhir Anand and Amartya Sen (2000) also acknowledge that the higher the average income of a country, the better its score on human development indicators like a higher life expectancy, lower infant and child mortality rates and a higher level of literacy. So although economic growth is not automatically linked to human

development (UNDP, 1990), income is still one of the most important means that people can have to enlarge their choices and increase their own development. Apart from that the GNI per capita method is also used to determine whether a country is developed or developing according to the Development Assistance Committee (DAC, 2010). Because of these reasons the growth of GNI per capita will be one of the main indicators in this thesis to measure development. *Annex 4* provides a more detailed discussion of the difference between two main instruments, the World Bank Atlas Method and the Human Development Index, to measure development.

Successful development

Now that it is said that development will be measured by looking at the growth of income per capita, the next question is how high this growth needs to be in order to be recognized as successful. Two things will be remarked about this. The first one is that the higher the economic growth of a country, the more means this country will have to follow a Low Emissions Development Path. Therefore the more economic growth increases a country has, the bigger the chance that it can follow a LED Path.

The second remark is that income inequality between developed and developing countries, when looking at GNI per capita, have been rising for the last two decades. However, the pace of the inequality growth has been slowing down, especially between 2002 en 2006. This is shown in figure 4.2. This figure shows that the difference in GNI per capita is still increasing, because the difference between the blue line and the red line is increasing in the left graph. However, when looking at the increase per capita in percentages in the right graph, it shows that between 2002 en 2006 the GNI of developing countries has increased by 38,1%, while the increase of GNI from developed countries has increased by only 20,9%. This means that the relative difference between these two groups of countries has decreased in this period of time.

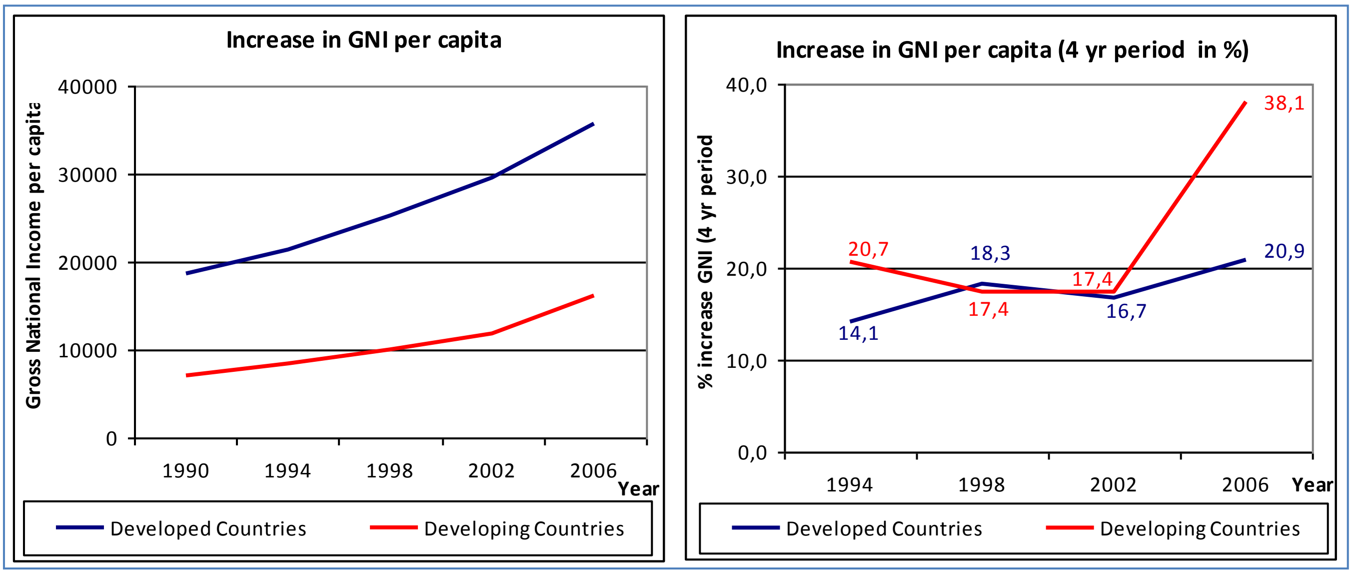


Figure 4.2: Increase in GNI per capita developed and developing countries

It should be noticed here that in the criteria for Low Emissions Development the focus will be on GNI Purchasing Power Parity (PPP). This means that the income per capita of different countries is looked at in relation to each other. For instance, fifty Euros which is exchanged and spent in Ghana will buy you more haircuts then fifty Euros spent in the Netherlands. Therefore PPP takes the lower costs of living into account and adjusts for it as though income was spent locally. In that sense it means that

PPP is the amount of a certain basket of basic goods which can be bought in the given country with the money it produces (Ward, 2002).

To come back at the question how successful development can be defined; this thesis will define successful development when the relative inequality between developed and developing countries is decreasing. In this case it is possible to look at the left graph of figure 4.2 and see that the period between 1994 and 1998 has not shown successful development, because the relative inequality between the developed and developing world has increased in that period of time (the blue line is higher than the red line). Al the other periods have shown successful development, between 1990 and 1994 6,6% higher, between 1998 and 2002 only 0,6% higher, but between 2002 en 2006 a whopping 17,1% higher.

Fewer emissions

Now that successful development has been defined, the last part of the definition of LED which has to be clarified is what exactly is meant by "fewer emissions than with business as usual". Paragraph 4.1 already explained what has to be kept in mind when talking about emissions. In this thesis emissions will refer to CO_2 emissions, which accounts for 70% of the anthropogenic global warming. So what does business as usual refer to? In general this means the amount of greenhouse gas emissions when no mitigation actions will take place. However, the difficulty is to define this amount. To define business as usual means to conduct politics. This means that it can be rewarding for countries to give the impression that the business as usual scenario means very much emissions, because in that way the real emissions will look like a big improvement compared to that high business as usual scenario.

The best way to deal with this is to set a certain standard for countries which tells them how many greenhouse gasses they may emit. In that way a more equitable partition can be made for different countries. This is because the business as usual scenario of different countries will not be the reference point, but a general standard will be the reference point. This means that a country which has a very high business as usual scenario will not have a dishonest advantage anymore. More importantly, with this method you can set a standard that gives more certainty that the two degrees Celsius border will not be crossed. This method will be elucidated later in this chapter.

4.4. Countries applying LED approach

The list of countries in table 4.1 is from the Low Carbon Development Strategies Project (2010a) and shows which countries apply Low Emissions Development Strategies. In the list both developing and developed countries have been included. Apart from the name of the country the list also includes the date the strategy has been commissioned, the name of the strategy and the time horizon which is applied in the strategy (Low Carbon Development Strategies Project, 2010a). This shows quite a lot of countries are involved at this moment in these Low Emissions Development Plans. The earliest plan is from China, which introduced the National Climate Change Program in June 2007.

Apart from these strategies a lot of studies are also being carried out by different organisations to map the possibilities and potential for Low Emissions Development Strategies in different countries. These studies show that different institutions are investing in LED Strategies for different countries. Two of the main institutions which look at the possibilities for LED strategies are the World Bank and the United Nations. *Annex 3* shows a list of countries which are conducting studies in LED, the name of the study, the organisation which initiated this study and the topics which will be studied.

Country	Date	Name	Time horizon
Bangladesh	Sep 2008	Climate change strategy and action plan	2009-2018
Brazil	Dec 2008	National Plan on Climate Change	2030
		Building a low Carbon Brazilian Economy	2030
Caribbean Community	Jul 2009	Climate Change and the Caribbean: A Regional Framework for Achieving Development Resilient to Climate Change	2009-2015
Chile	Sep 2008	National Action Plan on Climate Change	2007-2012
China	Jun 2007	National Climate Change Program (supporting the 11th 5 year programme)	2010
	Oct 2008	China's Policies and Actions for Addressing Climate Change	Current policies
EU	Jan 2008	EU Climate and Energy Package	2020
Germany	Dec 2007	The Integrated Energy and Climate Programme of the German Government	2020
Guyana	May 2009	Transforming Guyana´s Economy While Combating Climate Change	2020/2030
India	Jul 2008	National Action Plan on Climate Change (11th and 12th 5 year plans)	2017
	2008	Eleventh five year programme 2008	2007-2012
	Jan 2008	Building a low carbon Indian Economy	2030
Indonesia	Nov 2007	National action plan to combat climate change	2050
Japan	Jul 2008	Action plan for achieving a low carbon society	2050
Mexico	2007	National Strategy on Climate Change	2050
	Mar2009	Special Programme on Climate Change 2009	2007-2012
South Africa	Jul 2008	Long Term Mitigation Scenarios and policy framework	2050
	Mar2009	National Climate Change Response Policy	50 years
South Korea	Aug 2008	"Low Carbon, Green Growth" Vision - 1st National Basic Energy plan and Comprehensive Plan on Combating Climate Change	2008-2030
UK	Jul 2009	Low Carbon Transition Plan (National Strategy for Energy and Climate)	2020/2050

Table 4.1: Countries that apply Low Emissions Development Strategies source: Low Carbon Development Strategies Project, 2010a

The topics which are being studied are more or less the same. All of the topics include a Technology Needs Assessment (TNA) which "aims at defining clean technologies best suited for climate change mitigation and adaptation in target countries, and at developing Technology Action Plans (TAPs) to facilitate smooth transfer of the selected technologies" (National Renewable Energy Laboratory, 2010, p.1). Therefore these TNAs are an important aspect of a Low Emissions Development Strategy for the developing countries. With this tool it is possible to define what kind of actions will make a difference and what kind of actions will add no value at all. This information makes it possible to look what kinds of elements are part of a LED Strategy.

4.5. Elements of a Low Emissions Development Strategy

A LEDS combines different areas of policy related to climate change, energy and development together into one strategy. The aim of this strategy is to support development in a low emissions way (Low Carbon Development Strategies Project, 2010b). This kind of strategy can have two purposes. First of all it can align the policies which are related to climate change, energy and development. In this sense it ensures that these policy fields can synergise into an efficient tool to combat poverty and climate change, while at the same time ensuring energy security for inhabitants of that country. The second aim of a LEDS is to frame the international climate policy regime. In this sense it can form a basis for financial, technical, and other support from developed countries in a bilateral or multilateral relationship with the developing countries (ibid).

According to the Low Carbon Development Strategies Project (2010b), which has been set up by the Energy Research Centre of The Netherlands (ECN), the content of a LED Strategy consists of four building blocks. These building blocks are:

1. An analysis of the current situation which includes;
    a. Key stakeholders within the government, private sector, financial sector and civil society.
    b. Analysis of national GHG emissions data, inventories and models for long term emissions scenario's
    c. Climate change vulnerability and impact analysis
    d. Overview of existing policies and strategies, which include among others National Communications with the UNFCCC, TNAs, National Appropriate Mitigation Actions (NAMA) and National Adaptation Programmes of Action (NAPA)
2. A long term vision which includes the economic development of that country in a low emissions outline
3. A short to medium-term plan for implementation , which includes concrete climate mitigation and adaptation measures, assessment of appropriate technologies to meet those measures, overview of the associated costs and an overview of any gaps and barriers for implementation
4. Assessment of capacity building, financing and technology needs

These building blocks from the Low Carbon Development Strategies Project (2010b) seem to give a quite complete coverage of the contents of a LED Strategy. In a sense this overview of content is quite similar to what Project Catalyst (2009b) believes should be part of a LED Strategy, or a Low Carbon Growth Plan as they call it. According to Project Catalyst there are twelve elements within a nation's strategy to make its economy sustainable. These elements can be found in table 4.2:

Number	Element	Rationale
1	Vis ion	Framing the strategy within national priorities, global agreements and scientific projections
2	Time horizons for long term predictions and shorter term actions	
3	Reference to global target	
4	National baselines on GDP and emissions	
5	Analysis of abatement opportunities and costs	Analysis to identify best opportunities for emission abatement and adaptation based on science, economics and stakeholder impacts
6	Analysis of adaptation vulnerabilities and needs	
7	Identification of Priority areas	
8	Policies and measures	Planning to translate from vision to implementation
9	Institutional capacity	
10	Costs	
11	Abatement potential, targets	Linking between national plans and the global agreement to collaborate
12	Monitoring and review	

Table 4.2: Elements of LED according to Project Catalyst

source: Project Catalyst, 2009b

These elements from Project Catalyst (2009b) contain more or less the same elements as the building blocks of the Low Carbon Development Strategies Project (2010b). The biggest differences are that Project Catalyst includes the reference to a global target which should be part of a LED Strategy. The Low Carbon Development Strategies Project includes specific attention to Technology Needs Assessments which can define the best technologies at hand to combat climate change within one given country.

Adaptation in a LED strategy?
One aspect within these building blocks and elements is debatable. Both projects state that adaptation matters should also be part of a Low Emissions Development Plan. This is shown by the LCDS Project by including NAPAs as part of their building blocks and by Project Catalyst by stating that the strategy should include details to make the country resilient to unavoidable climate change. It can be questioned whether these elements are desirable in a Low Emissions Development Strategy. The reason is that there is a clear difference in mitigation actions and in adaptation actions. Mitigation actions aim to reduce greenhouse gas emissions via different strategies like changing to another type of fuel, reducing the amount of energy used or by changing the way land is cultivated. Adaptation actions on the other hand aim to deal with the consequences of climate change with strategies like building dykes, constructing irrigation systems and planting climate resilient crops. These types of actions have very different aims and contexts.

On the other hand it is possible to claim that development without adaptation matters is unsustainable, because such development is not capable of dealing with a changing environment and actions which take place right now, might turn up useless in the future because of this changing environment. The viewpoint in this thesis is that indeed adaptation actions are important, but this does not mean that they should not fall under a LED strategy, because of the different kinds of aims of LED and adaptation actions. Instead adaptation action should fall under the general development strategy of a country.

Five elements of a LED strategy
Taken the building blocks from the LCDS Project and Project Catalyst together, together with the critical note above it is possible to define the main elements of Low Emissions Development. These five main elements are vision, analysis, assessment, action and monitoring. Taken together into one picture figure 4.3 shows how these elements work together and what kind of subjects are part of the different elements.

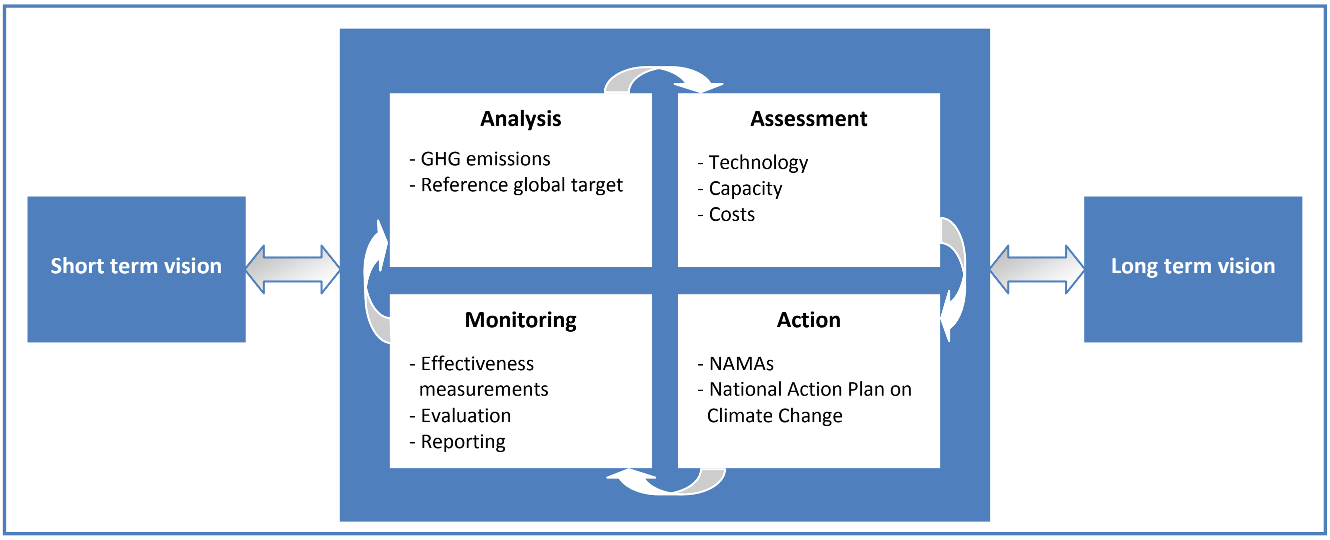


Figure 4.3: The different elements of a Low Emissions Development Strategy

This figure shows the main elements of a LEDS. Overall a *short term vision* and a *long term vision* are needed to be able to implement a LED strategy on the short and long run. These visions are needed in every stage of the process so they are standing next to all the other elements. They influence all the other elements during the whole process, but are also influenced by the elements themselves.

The next element is the *analysis*. This analysis is needed to know the current GHG emissions and how these emissions are holding up compared to a global target which can ensure that the average increase of temperature does not cross the two degrees Celsius border.

The third element is *assessment*. These assessments need to be made to find out what kind of technology will be needed, what the capacity is of the people and institutions who are to implement the action and where extra capacity is needed. Last but not least an assessment of the costs is also very important, together with a plan how these costs will be paid for. This could be done by government, other state donors, nongovernmental organisations and the private sector.

The fourth element is *action*. Most of the time the different kinds of action will be formulated in a NAMA. These NAMAs have been introduced in the Bali Action Plan from the UNFCCC (2007) in which was decided to launch a process by addressing enhanced national and international action on mitigation on climate change. Within this action consideration will be taken of "nationally appropriate mitigation actions by developing country Parties in the context of sustainable development, supported and enabled by technology, financing and capacity-building, in a measurable, reportable and verifiable manner" (UNFCCC, 2007, p.1). Apart from these NAMAs the National Action Plans of Climate Change also have been mentioned in this element. These are almost similar to NAMAs, but here the NAMA's have been worked out in an all-embracing policy plan. The countries Brazil, Chile, China, India, Indonesia, Mexico and South Africa all have implemented such a plan already.

The last element of a LED Strategy is the *monitoring*. This monitoring is important to measure the effectiveness of the plans and with this monitoring improvements can be made for the next strategy. After this monitoring there is a possibility to start all over again with analysis, assessments, actions and new monitoring. And again, during this whole process the short term and long term visions are intervening with the elements, but they are also being influenced by the elements itself.

4.6. Low emissions criteria for LED

Now that it is clear what the different elements of LED are this thesis will also have a look at criteria which can be used for LED. The last paragraph showed that one important element of Low Emissions Development is a reference to a global emission target. In that way more assurance can be given that the mitigation actions from both developing and developed countries are sufficient to keep the earth's temperature increase below the two degrees Celsius. Next to that the definition to emit less greenhouse gasses than business as usual is not clear enough, because it makes an unequal comparison between countries. Therefore this paragraph will focus on the criteria for low CO_2 emissions within LED.

Emissions per capita.

In general there are two ways to look at these CO_2 emissions. This can be done by looking at emissions per country or emissions per capita. Nowadays the international climate negotiations are focussing to set targets per country instead of a target per capita. In fact, in three mayor international climate agreements of the last 15 years, namely the Kyoto Protocol of 1997, the Bali Action Plan of 2007 and the Copenhagen Accord of 2009 the words 'per capita' are not mentioned. Nevertheless, the call to allocate emissions on a per capita basis instead of on a per country basis is getting stronger and stronger.

The emissions per capita target is backed up by quite some people and institutions: 1) Politicians like German Chancellor Angela Merkel and Indian Prime Minister Dr Manmohan Singh

(Bundesregierung, 2007), 2) Scientific institutions like The German Advisory Council on Global Change (WBGU)[2] and the Potsdam Institute for Climate Impact Research (PIK) (WBGU, 2009, Wicke *et al*, 2010) and 3) Individual researchers like Najam *et al*. (2003)[3] and Chancellor Professor of Sociology J. Timmons Roberts (2001). He writes that "global warming is all about inequality, both in who will suffer from its effects and in who created the problem in the first place" (Roberts, 2001, p. 501). He states that it is a basic rule of civil justice that those who create the mess should also be responsible to clean up that mess. From an ethical viewpoint there seems no good reason why someone from a developed country is allowed to emit more greenhouse gasses than someone from a developing country. Figure 4.4 shows that at this moment low middle income and low income countries are emitting much less carbon dioxide per capita compared to upper middle income and high income countries.

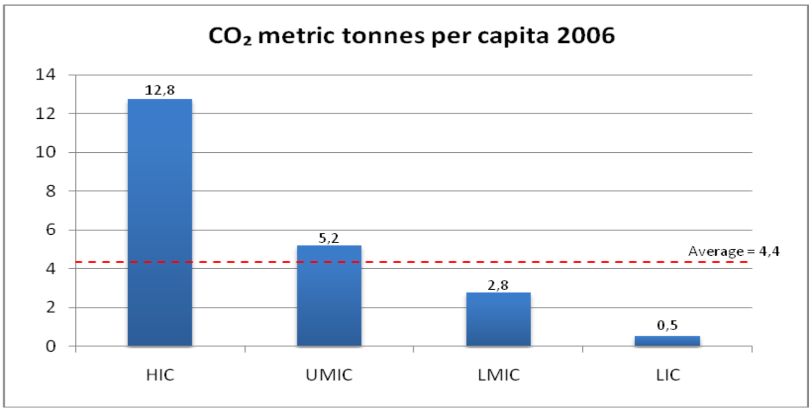


Figure 4.4: CO_2 emissions per capita in 2006 of different country groups (tonnes)

Apart from the ethical viewpoints there are some practical considerations too for this emissions per capita approach. First of all it ensures that international negotiations about greenhouse gas emissions can be less complicated, because no agreements have to be reached how much every individual country may emit. Secondly, it ensures that the least developed countries, which all emit much less CO_2 than average, are allowed to increase their emissions and therefore can focus their investments foremost on reducing poverty. Thirdly, it provides a tool for developing countries to sell any assets of emissions which their habitants have not used to developed countries (via a carbon market) and this can stimulate these countries to follow low emissions development (Wicke *et al*, 2010). Last but not least it can bring emissions per capita back to a more equal level and therefore is ethically more responsible. There are also limitations to this approach, described in box 4.1.

Box 4.1: Limitations to emissions per capita method

There are three mayor limitations with the allocation of greenhouse gasses per capita instead of per country. The first one is that *countries with a huge population will have an advantage,* for instance China and India, because they are allowed to emit much more emissions in total in comparison with countries with a small population. This can result in an unfair balance between the possibilities for different countries to invest in

[2] The WBGU consists of nine members, who are all professors and specialised in different fields, and argue for the so called budget approach to fight enhanced climate change. This budget approach means that a certain amount of CO_2 is allocated per capita and during further climate negotiations this "allocation of equal per capita emissions allowance should be applied as a first approximation" (WBGU, 2009, p. 22)

[3] Najam *et al*. (2003) write that "one potentially useful approach […] is to move towards a per capita emission targets and a 'contraction and convergence' policy scenario aimed at atmospheric stabilization in the post-Kyoto phase", (Najam *et al*, 2003, p. 227). However they do mention that this target should be adjusted to some mutually accepted bases like economic output per unit of carbon, climate zones and population density.

heavy industry. Countries with a big population have the possibility to compensate this heavy industry with hundreds of millions of people who emit below the sustainable average. Small countries have less means to make such compensation.

A second limitation for de emissions per capita allocation is that although this method might seem the most equitable one, it might not be very realistic to follow such path. Like described earlier none of the three mayor international agreements on climate change mentions the emissions per capita allocation. On the other hand this does not have to mean that countries should not try to pursue this allocation. Since the German Chancellor and the Indian Prime Minister both call for allocation of emission rights per capita, there is a possibility that such allocation might be part of international climate agreements in the future.

A third main limitation of the allocation of emissions per capita is that this method does not take into consideration the different kinds of geological features of a country. Countries with long and strong winters, like Finland or Canada, need to use more energy to keep their houses warm and therefore have a bigger incentive to emit more greenhouse gasses. Apart from that, countries with a lot of rich minerals in their ground, like gold or iron ore, will have to use a lot of energy to win those minerals from the ground. Therefore their incentives might also be stronger to emit more greenhouse gasses. However, this problem can be solved by international agreements which allow for carbon trading between companies and countries in order to keep their emissions per capita below an acceptable level.

Sustainable carbon dioxide emissions per capita

Now that it is clear why the emissions per capita approach is used, it is possible to look at the amount of emissions which every person can emit while the chance that the two degrees Celsius border will be crossed is minimized. According to the Carbon Dioxide Information Analysis Centre (CDIAC) humankind emitted 28,3 billion tonnes (Gt) of CO_2 in 2006 (CDIAC, 2010), with an average of 4,4 metric ton per capita in 2006. Roeckner, Giorgetta, Crueger, Esch & Pongratz (2010) from the Max Planck Institute in Germany state that fossil carbon dioxide emissions must be reduced by 56 per cent in 2050 and to near zero by the end of this century in order to achieve the long-term stabilisation of the atmospheric carbon dioxide concentration. *Annex 5* shows their model for the implied CO_2 emissions and the related increase in temperature. According to this scenario of Roeckner *et al*. (2010) the pathway to allowable fossil fuel emissions are characterized by a peak of around 10 Gt carbon (± 36,6 Gt CO_2) in 2015 and a strong decrease thereafter towards 3,4 Gt carbon in 2050 (± 11,4 Gt CO_2) in 2050.

The year 2050 is used in this thesis as target year in which countries should have an equal amount of greenhouse gas emissions per capita. 2050 has been chosen, because this is also the target year for the EU to reduce its carbon emissions by 80 – 95% (Hedegaard, 2010). Research by the European Climate Foundation (ECF) shows that this target is achievable (ECF, 2010). Next to that the year 2050 gives countries a substantial amount of time to equalize their emissions per capita.

With 2050 as target year it is possible to measure the emissions per capita which should be reached by then in order to reach the long-term stabilisation of carbon dioxide concentration according to the scenario of Roeckner *et al* (2010). What has to be kept in mind when calculating this is the increasing world population. According to the UN the world population will reach 9,149 billion in 2050 (UN, 2004, UN, 2008). This means that sustainable emissions will be 11,4 Gt CO_2 / 9,149 people = 1,24 metric tonnes CO_2 per capita[4] in 2050. This means the average emissions of 4,4 CO_2 tonnes per capita in 2006 will have to be reduced to 1,24 CO_2 tonnes per capita in 2050. *Annex 6* shows what this would mean for the low emissions pathway of different countries as well as the limitations to this model.

[4] 11,4 Gt CO_2 from the scenario of Roeckner *et al*. in 2050 divided by the 9,149 billion people in 2050 projected by the UN

4.7. Putting low emissions and development together

This chapter has given criteria for both development and low emissions for this thesis. Development in developing countries is characterized as successful when their growth of GNI per capita is higher than the average growth of GNI per capita of developed countries. Low emissions development means steady progress towards a common goal of sustainable greenhouse gas emissions per capita in 2050. When these two criteria are combined into one structure it can give a visualisation of what Low Emissions Development could look like. This is done by combining both the GNI per capita in purchasing power parity (PPP) and the carbon dioxide emissions per capita (in tonnes) into one graph. Figure 4.5 shows an example of this graph for Ghana, the case study of this thesis:

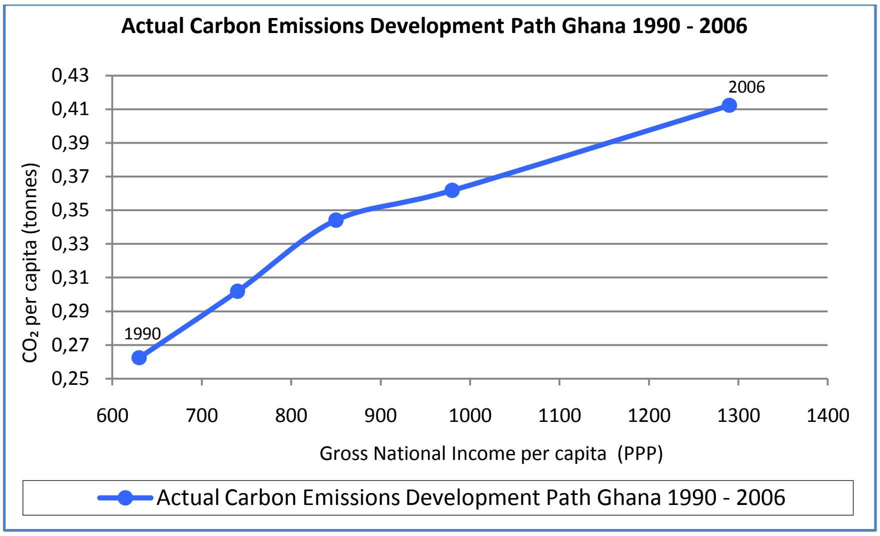


Figure 4.5: Actual Carbon Emissions Development Path for Ghana between 1990 and 2006

This shows that the emissions per capita of Ghana were 0,26 tonnes CO_2 in 1990 and increased to 0,41 tonnes CO_2 in 2006. In the same time its GNI PPP per capita increased from 630 US dollars equivalent in 1990 to 1290 US dollars equivalent in 2006. Altogether this graph gives a good impression on the Low Emissions Development path of Ghana between 1990 and 2006. Now the criteria for a Low Carbon Development Path will be added to this graph. This is done by taking the emissions and GNI per capita of 1990 as starting point and applying the criteria for LED for the following years.

A scenario for the LED path of Ghana

First the focus will be on the amount of carbon dioxide per capita that Ghana will have to increase or decrease every four years in order to reach the sustainable average of 1,24 tonne CO_2 emissions per capita in 2050. This is done by looking at the emissions of 1990 and calculating the equal steps this number will have to increase in order to reach the sustainable 1,24 tonne CO_2 per capita in 2050, which corresponds with the long-term stabilising scenario of Roeckner *et al*. (2010). In the case of Ghana, its emissions may increase every year by 0,0163 tonne CO_2 per capita in order to come from 0,26 tonne CO_2 per capita in 1990 to the 1,24 tonne CO_2 per capita in 2050.

Secondly the increase in GNI of Ghana will be compared with that of the High Income Countries. The reason is that successful development was defined as development in which the GNI per capita of developing countries increases faster than the GNI of developed countries. To measure this 1990

is taken again as a starting year each and the relative growth of Ghanaian GNI per capita is compared with that of the High Income Countries. The growth of GNI per capita in percentages of those HICs and the corresponding minimum for Ghana is shown in table 4.3:

	GNI growth HIC in % (4 years period)	Minimum GNI per capita for Ghana (compared with HICs)	Real Ghana GNI per capita	Real GNI growth Ghana in % (4 years period)
1990	-	630	630	-
1994	14	718	740	17
1998	18	847	850	15
2002	17	992	980	15
2006	21	1200	1290	32

Table 4.3: Growth in GNI per capita of Ghana compared to growth in HICs

This table shows that not every four year period has shown a bigger relative increase in GNI of Ghana compared to that of the HICs (the numbers in de last column are sometimes lower than those in the same row of the second column). However, in the 16 year period between 1990 and 2006 the GNI of Ghana has grown relatively stronger than that of the HICs and therefore the development path of Ghana for this period can be marked as successful.

Taken these criteria of emissions per capita and minimum GNI growth together it is possible to draw this minimum Low Emissions Development Path for Ghana in the same graph of figure 5.6.

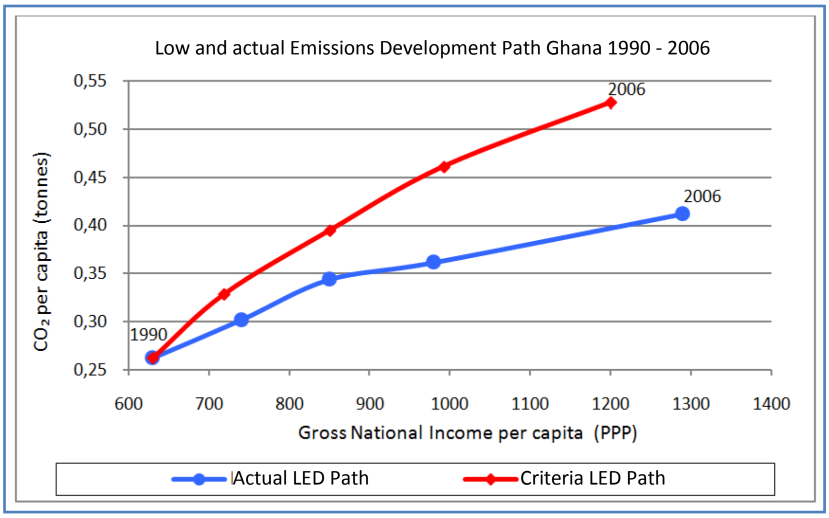


Figure 4.6: Scenario for a LED Path for Ghana compared to the actual LED path

In figure 5.7 the red line represents the minimum Low Emissions Development Path for Ghana. As the blue lines shows, Ghana has met the criteria for a LED path. This is because Ghana developed faster than the HICs (with a GNI per capita of 1290 US dollar equivalent instead of 1200 US dollar) and Ghana also emitted much less carbon dioxide in 2006 (0,41 tonnes per capita instead of 0,53 tonnes per capita). What has to be kept in mind is that it is very dependent upon which reference point is taken. When the Emissions Development Path of Ghana between 1990 and 2002 is looked at it can be determined that the carbon criteria are met (the blue line is lower than the red line), but in 2002 the development criteria are not met (the point in red line of 2002 is more to the right than the point of the blue line in 2002). Nevertheless, this tool gives a handy overview whether a developing country is following a Low Emissions Development path or not. See *annex 7* for more examples of developing countries and their low carbon development paths.

4.8. Benefits and limitations of the LED tool

Now that the elements and criteria of LED has been explained it is possible to look at the different benefits and limitations of this policy instrument. These benefits and limitations relate to both the effects on the organisational process around LED and on the context of LED.

Coherence of policy

The first and foremost benefit of LED is that it combines different kinds of related policy together into one strategy. Climate policy, development policy and energy policy are all combined in this plan and therefore it can form coherence and synergy in these policy fields. This is important, because without coherence and synergy it is very well possible that different kinds of policy are intervening with each other. This is also recognized by Paul Hoebink, a professor in Development Studies who states that coherence of policy is important in every field of policy, because objectives attained in one policy field could hamper the action taken in other relevant fields. "Coherence of policies should therefore be a general objective in all action taken by government" (Hoebink, 1999, p. 325).

A second benefit of LED is that it provides the international community with an innovative instrument to finance developing countries in their efforts to combat climate change. The Copenhagen Accord from December 2009 has generally been received with disappointment, because it did not yet provide the tools for countries to challenge climate change effectively. The benefit for LED is that it can still become an instrument in a new post 2012 climate change protocol, but it can also serve as new and separate instrument which could provide a base for bilateral agreements between developing and developed countries to combat climate change immediately. This means the success of LED does not have to depend on the success of international climate negotiations. Countries can start right away with mitigation actions and new flows of finance can make their way through LED to give developing countries more means to combat climate change.

Sovereignty

A third benefit of LED is that it can leave the sovereignty of developing countries intact, because the developing countries themselves can be made responsible for a LED strategy. This means that when countries have to prepare these LEDs themselves in order to receive funding to battle climate change, they will be more willing and capable to handle the content of the strategy. A major critique on similar plans to increase development, like the Poverty Reduction Strategy Papers (PRSP), is that a lot of these have been written by the World Bank in Washington and not by the countries themselves (personal communication, May 2010). Therefore these kinds of plans lack ownership, which is crucial to make poverty reduction effective. It is well known in development literature that "ownership of economic and political reform have progressively been identified as major determinants of aid effectiveness" (Santiso, 2001, p. 9).

LED has a good chance not to fall in the same trap. This does mean that investments in capacity building will be needed in the developing countries, so they have the means to set up a LED strategy. However, with the right incentives this is very well possible. A danger that lies herein is that as soon as LED strategies become part of international agreements the World Bank and other major donors will be tempted to take over this ownership. This is because the assessments for effectiveness of these donors can be partly dependent on the quality, feasibility and short term success of these LED strategies. This trap of ownership shift is something which will have to be watched for when a LED strategy becomes part of an international climate agreement.

Limited capacity, effectiveness and willingness

Of course LED does not only have positive sides. The first limitation has been touched upon in the description of the benefits and has to do with the limited capacity that developing countries can have, especially the Least Developed Countries (LDC), to set up a LED strategy that encompasses all the different parts of government and is implemented in the whole policy framework. This possible lack of capacity can take shape in one or more of the following components; 1) the lack of financial means to pay for policy makers and infrastructure to set up a strategy, 2) the lack of human capacity to lay down the means to set up a strategy and 3) the lack of experience, knowledge and knowhow to know where a LED strategy can be most effective and to know how the conditions can be met to collect (international) funding to implement a LED strategy.

The second limitation of Low Emissions Development is the effectiveness it can have on climate change. For the Newly Industrialized Countries (NIC) like China, Brazil, India, South Africa and Mexico it can be worthwhile to invest in mitigation actions. In 2006 these five countries combined were responsible for 31.1% of the worldwide CO_2 emissions. However, all the 43 Low Income Countries combined contributed only about 1.7% to the worldwide CO_2 emissions. Therefore it can be questioned if LED strategies should be applied in all the developing countries, because a decrease in the growth of the LIC emissions will contribute very little to stopping climate change.

On the other hand, it can be very worthwhile to invest right now in a low emissions economy in those countries, because with the right support the biggest effect in mitigation can be reached right now. To change a big high carbon intensity economy (like China), to a bigger low carbon intensity economy can prove to be more difficult than to change a small low carbon intensity economy, like Ghana, to a bigger low carbon intensity economy. This has to do with the so called carbon lock in which those bigger economies are trapped (personal communication, May 2010). The smaller economies on the other hand can make a leap frog in technology change and use the best available techniques to make the economy sustainable from the start up. The other side of this story is however that the big economies have more means and capacity to combat climate change.

The last limitation of LED is an ethical one. It has to do with the fact that the developed countries of today are responsible for the climate change which among others can threaten the development of developing countries. Therefore it is possible that developing countries do not feel it is their responsibility to combat climate change, but the responsibility of developed countries. This situation can cause some difficulty in the willingness of developing countries to set up LED strategies. Therefore the main motivation for developing countries to work on a LED approach might not be to battle climate change during development processes. Instead their motivation could be driven by the fear of being the 'black sheep' during climate negotiations or they might see possibilities to attract new financial support for development issues.

4.9. Conclusion

Looking back at this chapter it can be stated that important steps have been made in determining what Low Emissions Development means. It is shown that there is a clear difference between LED strategies for developing and for developed countries. Next to that the five main elements of LED have been put apart. These are: 1) vision, 2) analysis, 3) assessment, 4) action and 5) monitoring. Also the definitions and criteria for 'development' and 'low emissions' have been clarified. Development is regarded successful when the relative economic growth of developing countries is higher than that of developed countries. 'Low emissions' means working towards a target of a worldwide average of 1,24 tonnes of CO_2 per capita in 2050, in line with the long-term stabilisation of the atmospheric

carbon dioxide concentration introduced by the Max Planck Institute. Next to that the main benefits of LED have been explained, which are coherence of policy and increase of sovereignty. The main limitations are limited capacity, effectiveness and willingness of developing countries.

The model to put ‘development’ and ‘low emissions’ together in one graph gives an appropriate guideline for different countries in following a path towards a sustainable level of greenhouse gas emissions. It can bring the discussion to a further level in providing the first parameters for countries to determine whether they are following a Low Emissions Development path or not. Therefore this model is helpful for this thesis in defining Low Emissions Development. With this definition it can become clear whether the electricity sector of Ghana is following a LED path and if not, how much work must be done before it does follow a LED path. Therefore this chapter supports the main question of this thesis, ‘*what is the possible contribution of The Netherlands to a Low Emissions Development Strategy in the electricity sector of Ghana?’,* by defining what Low Emissions Development really encompasses.

Now that this defining of LED and finding criteria is finished it is helpful to have a look at the case study of this thesis, namely Ghana. Since this thesis focuses on the electricity sector of Ghana the next chapter will look in which way this electricity sector itself is following a LED path and how a LED strategy could help to reach such a path. First of all focus will be laid on the electricity sector of Ghana itself and the policy arrangement approach will be used to show the framework of this sector.

5 Electricity sector in Ghana

In the previous chapter this thesis looked into the elements of LED and developed criteria to define whether a country follows a LED path or not. In this chapter focus will be on the case study of this thesis, which is the electricity sector of Ghana. The criteria which have been introduced in chapter four can also look whether a sector, like the electricity sector, within one country follows this kind of path.

First of all this chapter will focus on the energy mix of Ghana and the electricity mix within that energy mix. Next the focus will be on the history of the electricity sector of Ghana. In the third paragraph this thesis will look at the question whether Ghana is following a Low Emissions Development Path if the electricity sector will continue on a business as usual scenario. After this paragraph the policy arrangement approach will be used to map the electricity sector and its policy. When all the dimensions of this policy arrangement within the electricity sector of Ghana have been covered this chapter will aim to answer the question '*which dimensions from the policy arrangement approach are crucial to influence the growth of prosperity in Ghana and of the carbon emissions in the electricity sector of Ghana?*

5.1. Energy mix of Ghana

The Energy Commission of Ghana published a report in 2008 on the Energy Statistics of Ghana which provides data on Ghana's energy situation from 2000 to 2008 (Energy Commission Ghana, 2008). Figure 5.1 and 5.2 show how these data provide an overview of the energy mix for both the primary and the secondary energy supply for Ghana. The primary energy supply refers to energy commodities that are either extracted or captured directly from natural sources such as crude oil, woodfuel etc. The secondary energy supply refers to energy from all sources that result from transformation of primary sources, like charcoal from woodfuel and gasoline from crude oil (Energy Commission Ghana, 2008).

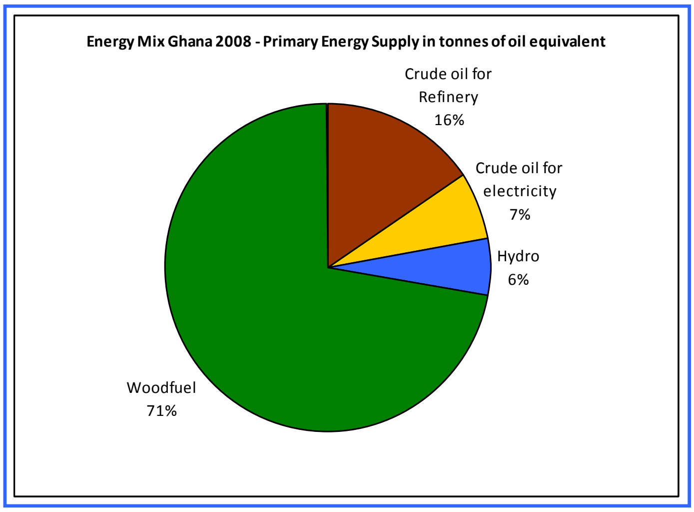


Figure 5.1: Energy Mix Ghana 2008 - Primary Energy Supply

Figure 5.1 shows that the primary energy supply of Ghana consists mostly of woodfuel (71%), followed by crude oil for refinery (16%), crude oil for electricity (7%) and hydropower (6%). This reflects that most people in Ghana still use biomass as their main source of energy. Figure 5.2 shows that the biggest part of secondary energy supply of Ghana in 2008 consisted of charcoal (50,7%),

followed by firewood (29,8%), petroleum (12,4%) and finally electricity (7,1%). Of the 12,4% petroleum about 4,1% consisted of gasoline, 3,6% gas oil, 2,2 % Residual Fuel Oil (RFO), 1,7% Kerosene, 0,6% Liquefied Petroleum Gas (LPG) and 0,2% Aviation Turbine Kerosene (ATK).

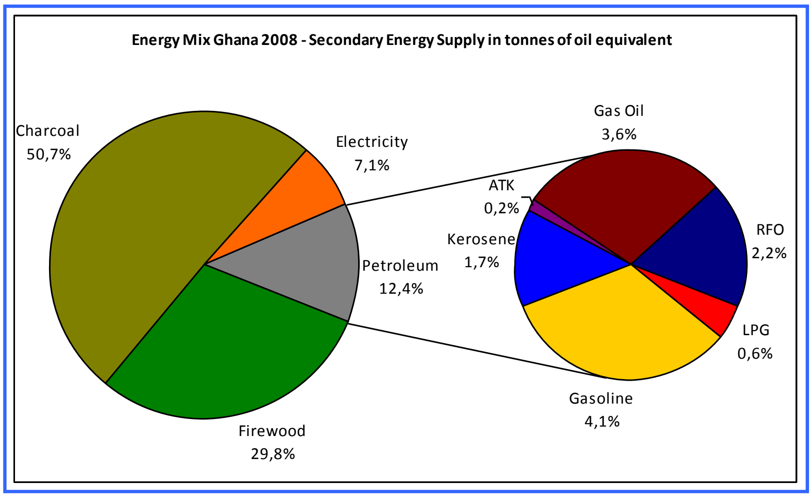


Figure 5.2: Energy Mix Ghana 2008 - Secondary Energy Supply

These two figures show that electricity is only a very small part of the total energy supply of Ghana. When focus is put on this electricity sector it is possible to look at the energy mix of installed capacity of Ghana in 2008. This is shown in figure 5.3.

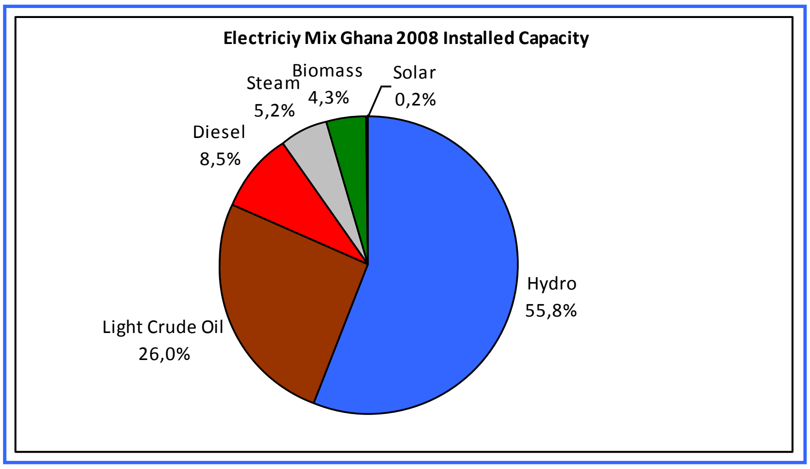


Figure 5.3: Electricity Mix Ghana 2008 – Installed Capacity

It should be noted here that this figure only refers to the installed capacity of Ghana. This means that the actual usage of these energy sources will be quite different. To illustrate this point; the 8,5% installed capacity of diesel consists for a large part of emergency diesel units, which can be used in time of energy crisis or as a backup when the electricity supply fails. These emergency units have not been used as extensively in 2010 compared to the year 2007 and 2008 when there was an energy crisis going on in Ghana (personal communication, May 2010). This has to be kept in mind when calculating the amount of carbon dioxide which these different energy sources emit, which will be done in the next paragraphs. First focus will be laid on the history of the electricity sector itself.

5.2. History of the electricity sector of Ghana

There are three main periods of electricity in Ghana. The 'Before Akosombo' period, the 'Hydro Years' and the 'Thermal Complementation'. The first one, 'Before Akosombo', refers to the period before the construction of the Akosombo Hydroelectric Plant and lies between 1914 and 1966. At this stage "electricity supply in Ghana was carried out with a number of isolated diesel generators dispersed across the country as well as standalone electricity supply systems" and "the first public electricity supply in the country was established in Sekondi in 1914". (Aryeetey, 2005, p. 17). The total electricity demand before the construction of the Akosombo dam cannot be determined due to the dispersed nature of supply resources, but a proxy of 70 MW is used as the level of electricity demand before the construction of Akosombo (Aryeetey, 2005).

The idea to build the Akosombo Hydropower Plant was developed in 1915 by Sir Albert Kitson, who was appointed by the British Colonial Office to establish the Geological Survey Department. He saw the potential of the Volta River as a source for hydro electricity to make deposition of bauxite possible. He had discovered this bauxite in the region the previous year (VRA, 2010). This idea was taken up later by the government which established the Volta River Authority (VRA) with the enactment of the Volta River Development Act (Act 46) in 1961. The VRA was charged with the responsibility for the construction of the Akosombo dam and the resettlement of people living in lands to be inundated (Aryeetey, 2005). The construction of the dam commenced in 1962 and was completed and formally commissioned in 1966. The original four generating units were extended with two additional units in 1972, bringing the total installed capacity at 912 MW. The Volta Lake which was created following the completion of the dam covers an area of 8500 km² and is the world's largest manmade lake in surface area (ibid) – see figure 5.4.

After completion of the Akosombo dam the Kpong Hydroelectric Plant was also successfully commissioned in 1982 and gave an additional 160 MW of installed capacity to the existing hydroelectric capacity. However, the most severe drought recorded in history in the Volta Basin occurred between 1982 and 1984. This meant that the total inflow into the reservoir over this three year period was less than 15 per cent of the long-term expected total. Electricity supply during this period was constantly rationed and this caused big problems for a new aluminium smelter which has been constructed in 1967. This 200.000 tonne smelter was owned by the Volta Aluminium Company (VALCO) and was the anchor customer of VRA. Between 1979 and 1982 VALCO consumed more than twice the amount of energy which was consumed domestically (Aryeetey, 2005). However, the severe drought meant that supply to VALCO was completely curtailed and this meant the end of the 'Hydro Years' (1966 – mid 1980's) and the beginning of the 'Thermal Complementation' period.

The Thermal Complementation period

After the drought in 1983 VRA undertook a comprehensive expansion study named the *Ghana Generation Planning Study*. This engineering planning study confirmed the need for a thermal plant to provide a reliable complementation to the hydro generating sources at the Kpong and Akosombo power plants. The main consideration for this complementation was the highly variable flows from year to year in the Volta River. The variation in flow between its highest inflow in 1963 and the lowest in 1983 was *10:1*. Therefore by adding the thermal complementation to the all-hydro system the vulnerability would be highly reduced, because the thermal plants could be used to meet the shortfall in demand resulting from low inflow of water and the reduced hydro generation. In that effect the thermal generators were to serve as an insurance policy against the poor hydrological years to meet the demand of electricity in Ghana (Aryeetey, 2005).

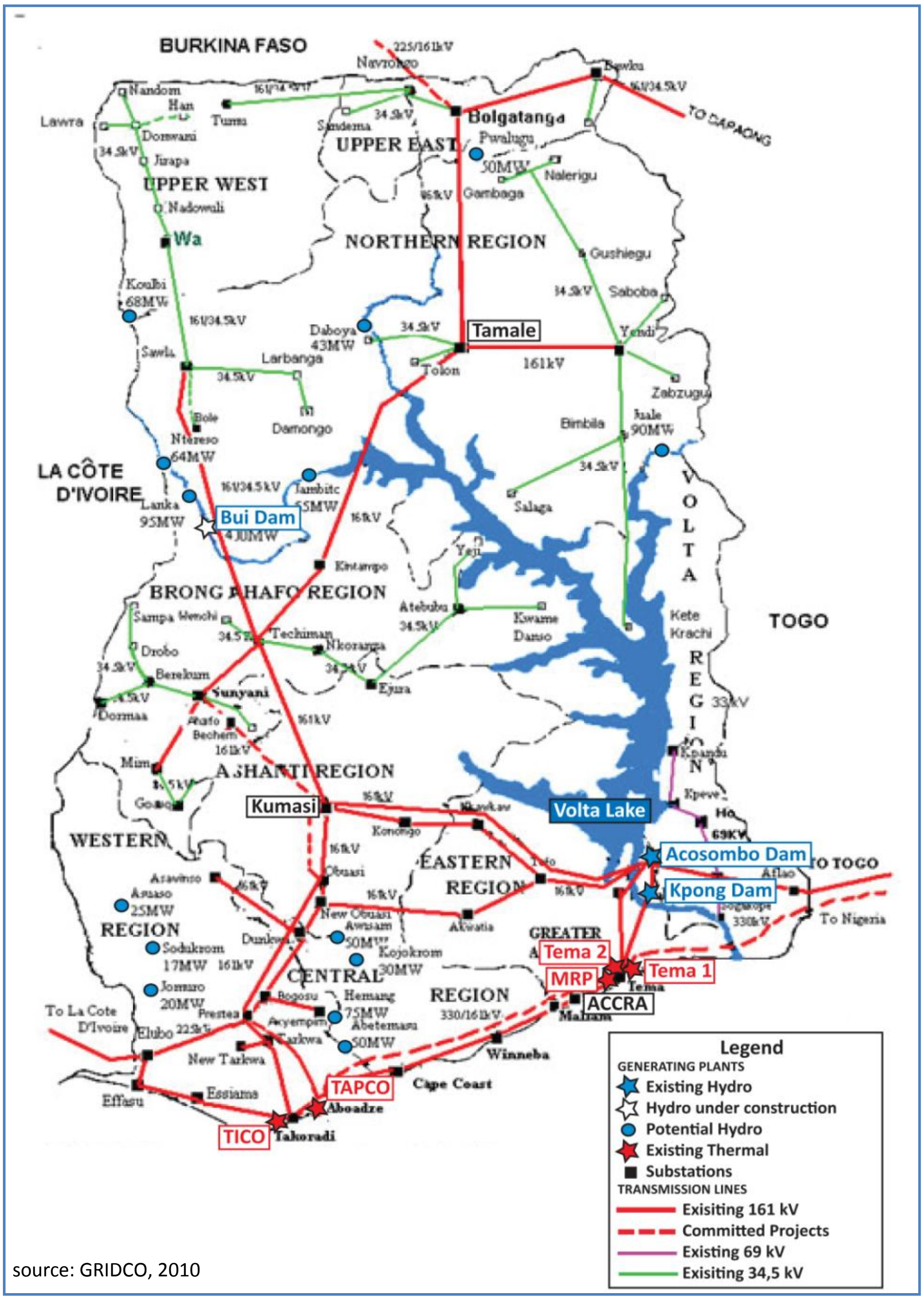


Figure 5.4: Map of Ghana with main electricity generation plants and transmission lines

The three main thermal plants that were built during this period are the 30 MW Tema Diesel Power Plant (which is not operational anymore), the 330 MW Takoradi Thermal Plant Station (TAPCO) and the 220 MW Takoradi Thermal International Company (TICO). The construction of this last plant, TICO, has become possible after an energy crisis in 1998. In this period of time the Ghanaian government contracted two international emergency power producers. After this crisis a new policy framework was developed which envisaged the introduction of private sector participation (Aryeetey, 2005). However Lartey (2009) writes that "the main factor for this process of liberalisation was the pressure on the government from the international funding agencies led by the World Bank to open the industry to competition due to change in their policies towards funding of electricity projects"(Lartey, 2009, p. 3)

New Developments

This beginning of liberalisation of the electricity market opened the door for the development of different power plants:

- A 200 MW Sunon Asogli Plants which is under construction right now.
- A 110 MW plant at Tema, the so called Tema 1 Thermal Plant which has just been constructed.
- A 50 MW power plant, the so called Tema 2 Power Plant, which has also just been constructed.
- Plans for expansion of Tema 1 by the 125 MW Tema Osonor Power Plant which will generate electricity via a turbine operating in open cycle (MacDonald, 2008).
- There are plans to upgrade TICO with Heat Recovery Steam Generators to generate an additional 110 MW via a Steam Turbine Generator[5].
- The Akosombo plant was retrofitted in 2005 and this increased the plant's output from 912 MW to about 1065 MW.
- A third Hydro plant, the 400 MW Bui Hydro Electricity Project, is under construction near the Black Volta River.
- There are some plans for additional hydropower projects (Western River and Juale & Pwalugu), but the realisation of these projects is uncertain.

Table 5.1 in the next paragraph also gives an overview of all the different power plants which are currently operational. Figure 5.5 shows the electricity generation between 1980 and 2006:

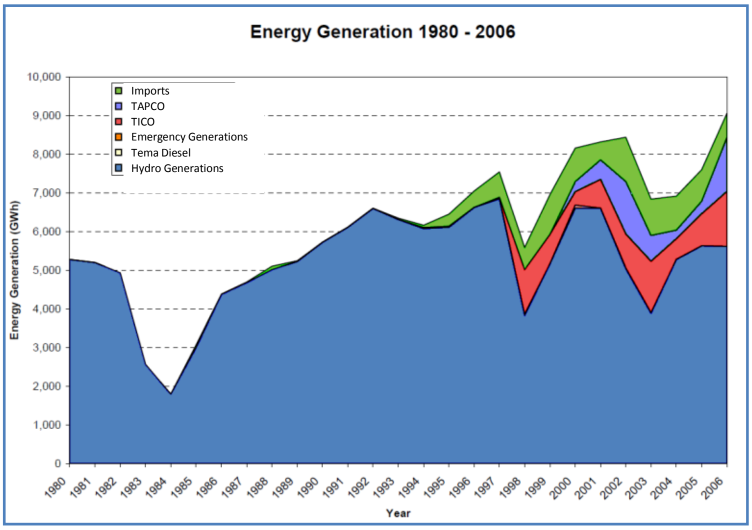


Figure 5.5: Energy Generation Ghana 1980 - 2006 source: VRA, 2007

The main power source for the thermal plants for the last decade(s) has been Light Crude Oil. However, this is slowly changing. At this moment the thermal stations are being retrofitted to be able to run on natural gas (personal communication, May 2010).

The West African Pipeline

This retrofitting of the thermal stations has to do with the finalization of the West Africa Gas Pipeline (WAGP). This project intends to supply natural gas from Nigerian oil and gas fields to locations in

[5] At this moment the 330 MW TAPCO Plant already has a 2-2-1 configuration, meaning two (2) of these 110 MW combustion gas turbines, with two (2) Heat Recovery Steam Generator which feed one (1) 110 MW Steam Turbine Generator

Ghana, Benin and Togo through a 681 km long pipeline, starting from the Lagos coast and terminating at Takoradi (Sachdeva *et al*., 2004).

> The WAGP would lead to a significant regional economic integration and benefits by making available an abundant energy resource for rapid growth. It would also lead to significant gas flaring reduction in Nigeria. In addition specific benefit to Ghana would accrue from replacement of the light crude oil currently begin used as fuel for thermal generation (Sachdeva *et al*., 2004, p. 83).

This means that due to the cost difference it is most likely that the thermal power plants will be using natural gas as power source in the future. At this moment the pipeline has just finished so the first gas has begun to run between Nigeria and Ghana. The compression units are being built in order to be able to use the gas for the thermal plants (personal communication, May 2010). However, at this moment VRA has a contract with the Nigerian government that it can buy a maximum of gas supply to power 400 MW combustion turbines. VRA has asked for an increase of that amount, but so far without success. This has to do with problems in the gas sector of Nigeria and it is questionable if VRA will be able to increase this amount of gas flow in the near future (personal communication, 2005). Nevertheless almost all the thermal stations are retrofitted to be able to use natural gas and all the plants under construction and planned will also use this fossil source to generate electricity in the future.

Investments in Renewable Energy

Apart from these hydro and thermal sources Ghana has also invested lately in renewable energy, although these developments are still in their infancy. According to the Renewable Energy Department at the Ministry of Energy (MoE) of Ghana there are over 5000 solar power installations in Ghana which have a total capacity of around 4 MW. Next to that some large sawmills and Oil Palm Mills are known to operate Combined Heat and Power plants based on biomass wastes to generate essentially steam for their operations and some amount of electricity to supplement their grid electricity supply. Altogether these biomass installations have a capacity of around 90 MW. Wind energy is very limited in Ghana (there are a few units which generate up to 12 KWh), but there are plans to increase this capacity in the near future. Studies are being done by private investors to build Wind Farms which have a capacity of up to 300 MW. At this moment however there is still large uncertainty about the realisation of these projects.

Discovery of oil in Ghana

The most recent episode in the history of the electricity sector of Ghana has to do with the discovery of oil and gas in 2007 off the coast of Ghana. During drillings in the Jubilee Field the company Kosmos discovered an oil field which contains between 500 and 1500 million barrels of oil together with natural gas reserves (Breisinger *at* al, 2009). At this moment the policy implicates to export all the oil to other countries. A recent report from the World Bank (2009b) estimates that at the peak 120.000 barrels of oil per day can be extracted and the government revenue could reach 1 billion US dollars per year between 2011 and 2029. Next to the oil the amount of gas which can be attracted from the Jubilee field is about 3,4 million cubic meters of gas per day. Because this is dry gas and cannot be easily be stored and exported, this would mostly be used for own consumption and to power the Ghanaian thermal plants.

Concerning flaring, the policy of Ghana is not to flare any gas when oil is being extracted from the Jubilee field. Therefore investments have been made to build infrastructure to re-inject the gas back

into the fields when the oil is being drilled. However, this re-injection of gas is a very expensive procedure. Some donors and NGO's expressed their concern whether this policy will be followed and if really no flaring will occur when oil will be extracted from the Jubilee field. Time will tell if the Ghanaian government has the capacity and the political will to follow this 'no-flaring policy'.

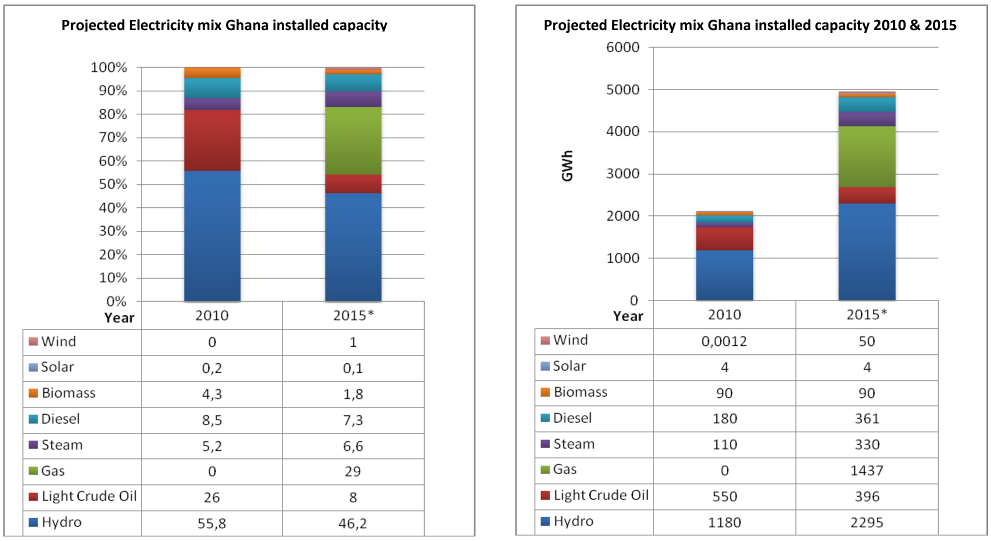
5.3. Low Emissions Development Path of Ghana with business as usual

Now that it is clear what the energy and electricity mix of installed capacity in Ghana looks like it is also possible to look what the LED path of Ghana will be with a business as usual scenario. First of all table 5.1 shows which kind of electricity generators form the electricity mix of Ghana:

Plant	Type	Fuel	Units	Installed capacity (MW)	Electricity generated in 2008 (GWh)	Percentage of GWh
Akosombo	Hydro	Water	6	1020	5321	63,5
Kpong	Hydro	Water	4	160	968	11,6
TAPCO	CC Thermal	Light Crude Oil / Steam	3	330	888	10,6
TICO	SC Thermal	Light Crude Oil	2	220	1026	12,2
Tema 1 Thermal Plant	SC Thermal	Light Crude Oil	1	110	0,3	< 0,1
Tema 2 Power Plant	Thermal	Diesel	1	50	-	-
Emergency Diesel Units	Diesel generators	Diesel	50	50	132	1,5
Mines reserve plant (MRP)	Thermal	Diesel	3	80	44	0,5
Renewables		Biomass, Solar & Wind	+ 5000	94	-	-
TOTAL				**2114**	**8379,3**	**100**

Table 5.1: Installed electricity capacity in Ghana   Source: Personal communication with VRA, 2010

When looking at all the power plants which are now under construction or which are now planned a graph can be made for the expected increase in the near future (figure 5.6).



Year	2010	2015*
Wind	0	1
Solar	0,2	0,1
Biomass	4,3	1,8
Diesel	8,5	7,3
Steam	5,2	6,6
Gas	0	29
Light Crude Oil	26	8
Hydro	55,8	46,2

Year	2010	2015*
Wind	0,0012	50
Solar	4	4
Biomass	90	90
Diesel	180	361
Steam	110	330
Gas	0	1437
Light Crude Oil	550	396
Hydro	1180	2295

Figure 5.6: Projected Electricity Mix Ghana 2015 – Installed Capacity

This figure shows that at this moment hydro has the biggest capacity for electricity generation in Ghana and this will remain the same in 2015, its share will decrease compared to other sources. The graphs also give a good view of the consequences of the construction of the West African Gas Pipeline. The amount of gas which can be used in the future to power the thermal plants is difficult to estimate, because it is dependent on different aspects, like the price of fossil fuels, the kind of contracts with Nigerian gas suppliers and the feasibility to use gas from the Jubilee field for own consumption in the next few years. In this graph the usage of oil and gas by power plants which can use both has been assumed to be a 50 – 50 share.

However, as noted in the first paragraph of this chapter, the installed capacity is something rather different than the actual electricity generated by these electricity generators. Therefore the last column of table 5.1 shows the amount of GWh which has been generated in 2008. The data in this column have been retrieved from the Volta River Authority (personal communication, May 2010). It should be noted here that the GWh of renewable energy has not been filled out. This has to do with a lack of data, but also because it became clear from interviews with employees from the renewable energy department of the Ghanaian government that the current share of renewable energy within the electricity mix is somewhere between 0.2 and 0.3 % (personal communication, May 2010). This is such a small amount that leaving these numbers out will not change the results drastically.

One other uncertainty is the amount of electricity which is being generated by backup generators. There is no information on the total installed capacity of these standby generators countrywide, but estimates have been made from the recorded hours of power outages and the quantity of industrial and commercial share of diesel consumption (table. 5.2)

	Power outages (hours)	Industrial and commercial share of diesel (tonnes)	Estimated power generated by backup systems (GWh)
2001	704	45000 – 64000	138 – 194
2002	501	33000 – 48000	101 – 145
2003	485	34000 – 49000	103 – 149

Table 5.2: Estimated share of GWh generated by backup generators

Source: Energy Commission, 2006

These numbers give a rough estimation on the amount of GWh generated by these backup systems in 2008, presuming that the hours of outages did not change significantly. However, this would be a good guess at best[6] and therefore the backup systems will not be used in the business as usual scenario.

Estimates of carbon dioxide emissions in the electricity sector of Ghana in 2008

Now that it is clear from table 5.1 what the load factor of the main electricity generators was in 2008 a rough estimation can be given of the amount of carbon dioxide which has been emitted by the different generating plants. To measure this amount of CO_2 this thesis uses the study from the International Atomic Energy Agency (IAEA) which looks at greenhouse gas emissions of electricity generation chains (Spadaro *et al.*, 2000) and the Vattenfall's Life Cycle Studies of Electricity (Vattenfall, 1999). These studies give general emissions from different power sources and their numbers are shown in table 5.3[7]:

Study	Gas	Oil	Hydro	Wind
IAEA	444	802	16	7
Vattenfall	436	809	3,5	5,5
AVERAGE	440	806	16[8]	6

Table 5.3: General emissions from different power sources (CO_2/GWh)

Because of the uncertainty about the real emissions the numbers shown in table 5.4 are not accurate numbers but rough estimations of the real emissions from the electricity generators. However, these

[6] It would be a guess because of the lack of information about the real amount of GWh generated, the kind of backup systems and what kind of diesel is being consumed by these. Further research in the usage of these backup systems will be needed to justify any reporting on these systems.

[7] It must be noted here that to measure the carbon dioxide emissions from specific electricity generators with numbers from the general averages which are given by IAEA and Vattenfall is very risky. This is because there is no certainty that the specific electricity generators in Ghana emit an amount of CO_2 which is close to the general average, in fact they could be way off. However, this method is chosen due to lack of data (VRA does not calculate emissions from their power plants) and lack of time.

[8] The average of the IAEA has been chosen, because they compare different hydro plants worldwide, while Vattenfall only looks at the plants in Sweden. For hydro plants these differences can be severe due to differences in geography and therefore the IAEA study is considered to give a more accurate average.

rough estimations can still give clear insights into the business as usual scenario and in what way this scenario goes together with a Low Emissions Development Path.

Plant	Type	Fuel	Installed capacity (MW)	Electricity Generated in 2008 (GWh)	CO_2 emissions (tonnes)	CO_2 emissions per capita (tonnes)
Akosombo	Hydro	Water	1020	5321	85136	0,00364
Kpong	Hydro	Water	160	968	15488	0,00066
TAPCO	Combined Cycle Thermal	LCO / Steam[9]	330	888	476560	0,02040
TICO	Single Cycle Thermal	LCO	220	1026	825930	0,03535
Tema 1 Thermal Plant	Single Cycle Thermal	LCO	110	0,3	241,5	0,00001
Emergency Diesel Units	Diesel generators	Diesel	50	132	106260	0,00152
Mines reserve	Thermal	Diesel	80	44	35420	0,00455
TOTAL			**1970**	**8379,3**	**1545036**	**0,06612**

Table 5.4: CO_2 emission estimates from installed electricity generators in Ghana in 2008

Estimates of carbon dioxide emissions of the electricity sector of Ghana in the future

Now that an estimation of the emissions of the electricity generators in 2008 has been given, emissions at a certain point in the future can also be estimated. This point has been set at 2015, because the VRA forecast for GWh generation in the future goes until 2015. Table 5.5 gives an overview of the different kind of electricity generators which will generate power in 2015 according to VRA and which one will be commissioned in the near future.

Plant	Type	Fuel	Units	MW	GWh in 2015
Akosombo	Hydro	Water	6	1020	4415
Kpong	Hydro	Water	4	160	885
Bui	Hydro	Water	1	400	1000
TAPCO	Combined Cycle Thermal	LCO/Gas – Steam	3	330	1840
TICO + Expansion	Combined Cycle Thermal	LCO/Gas – Steam	3	330	2103
Sunon-Asogli Power 1	Combined Cycle Thermal	LCO/Gas	6	180	1340
Takoradi 3	Combined Cycle Thermal	LCO/Gas	1	130	295
Tema 1 Expansion	Single Cycle Thermal	LCO/Gas – Steam	3	330	2235
Osagyefo Power Barge	Single Cycle Thermal	LCO	2	125	657
KTPP 1	Single Cycle Thermal	Diesel/Gas	2	230	-
KTPP 2	Combined Cycle Thermal	Steam	1	110	-
Cen Power	Combined Cycle Thermal	Gas	3	400	-
Sunon-Asogli Power 2	Combined Cycle Thermal	Gas	3	360	-
Western River Hydro	Hydro	Water	?	625	-
Juale & Pwalugu Hydro	Hydro	Water	?	90	-
Wind Power	Wind	Wind	?	50	-
TOTAL				**4870**	**14770**

Table 5.5: Electricity generators in Ghana in the near future

In table 5.5 the last seven power stations are either under construction or the construction is expected to commence before the end of 2010 and be available by 2013, according to the Energy Commission (2010). However, according to the forecast of the VRA only the first nine power plants from table 5.4 will generate power in 2015. Therefore the business as usual scenario in this thesis will only look at these electricity generators and only include the projected CO_2 emissions from these plants.

[9] For the combined cycle plant of TAPCO one third of the generated electricity is being powered by steam which is the spin-off of the other two turbines. Therefore the carbon dioxide of this plant has been measured by dividing the average oil emissions of these combined cycle oil powered plants by ⅔. There is a slight bias in this number, because powering the steam turbine generator, even with a spin-off product like steam, will always contribute to carbon dioxide emissions.

There are two points which should be noted before CO_2 emissions of these plants are estimated. First of all five of the nine power plants which will operate in 2015 will be able to generate electricity either with Light Crude Oil or with Gas. Like stated before, VRA has a contract with the Nigerians for enough gas to run 400 MW of the turbines on gas. However, the actual gas flow in 2015 will also, apart from the contract with the Nigerians, depend on the price of the different fuels and the potential gas supply from Ghanaian own Jubilee field. Therefore calculations have been made which show the business as usual scenario when all the five power plants will run Light Crude Oil, when the five power plants have gas to run 400 MW of the turbines on gas and when the power plants have enough gas to run totally on gas in 2015.

The second point is that there is some uncertainty whether two expansions, the TICO expansion and the Tema 1 expansion, will be constructed and finalized before 2015. Both these expansions mean the introduction of Heat Recovery Steam Generators which feed a 110 MW Steam Turbine Generator. This means that the single cycle power plants will convert into a combined cycle power plant and which is an energy efficiency measure. However, Lartey (2009) draws attention to the fact that this upgrade has been planned for a while, but so far without success[10]. This shows the difficulty for the expansion plans to upgrade a single cycle power plant like TICO into a combined cycle power plant. Therefore the measurement of carbon dioxide in a business as usual scenario will also take the possibility into account that these expansions have not been commissioned yet in 2015.

Taking these two points into consideration table 5.5 shows the CO_2 emissions in the business as usual scenario for the nine power plants that will be operational in 2015 within the six different scenarios:

Plant	GWh in 2015	CO_2 emissions 100% gas with expansions	CO_2 emissions 100% gas without expansions	CO_2 emissions 100% LCO with expansions	CO_2 emissions 100% LCO without expansions	CO_2 emissions 400 MW gas with expansions	CO_2 emissions 400 MW gas without expansions
Akosombo	4415	70640	70640	70640	70640	70640	70640
Kpong	885	14160	14160	14160	14160	14160	14160
Bui	1000	16000	16000	16000	16000	16000	16000
TAPCO	1840	539733	539733	987467	987467	849703	849703
TICO + Expansion	2103	616880	925320	1128610	1692915	971155	1456732
Sunon-Asogli Power 1	1340	589600	589600	1078700	1078700	618805	618805
Takoradi 3	295	129800	129800	237475	237475	136229	136229
Tema 1 Expansion	2235	655600	983400	1199450	1799175	1032112	1548167
Osagyefo Power Barge	657	289080	289080	528885	528885	528885	528885
TOTAL	**14770**	**2921493**	**3557733**	**5261387**	**6425417**	**4237688**	**5239321**
TOTAL per capita in 2015 (tonnes)		***0,1085***	***0,1321***	***0,1954***	***0,2386***	***0,1574***	***0,1946***

Table 5.6: Estimated CO_2 emissions in BAU scenarios for nine operational power plants in 2015

Criteria for the electricity sector in 2015

Now that the carbon dioxide emissions per capita have been projected it is also possible to have a look at the criteria to measure development within this sector. Since this thesis refers to development as GNI per capita, the focus can be laid on the different amounts of GWh needed in different GNI scenarios. The Energy Commission calculated three different demand projections for GWh in 2015 for a 'low economic growth' scenario, a 'moderately high economic growth' scenario and a 'high economic growth' scenario:

[10] This has to do with the case that the private investor that owned 90% of TICO, an American company named CMS Energy, wanted the guarantee of the Ghanaian government for VRA's obligations under the contract to upgrade TICO. Because the government refused to guarantee these obligations of VRA under the draft contract CMS eventually sold its interest in TICO to the international company Abu Dhabi National Energy Company PJSC (TAQA).

Scenario	Economic growth
Low economic growth	2 - 4 %
Medium economic growth	5 - 7 %
High economic growth	8 - 10 %

Table 5.7: Different economic growth models and corresponding growth percentage Source: Energy Commission Ghana, 2006

The International Monetary Fund (IMF) forecasts that the economic growth of the high income countries will hover around the 2,3 per cent in the next two years (IMF, 2010). Apart from that the average economic growth of the high income countries has been 1,97% per year in the last ten years (World Bank, 2008). Therefore it can be assumed that the 'low economic growth' scenario which the Energy Commission has set out will be sufficient to meet the criteria of LED. This is because the two to four per cent increase in economic growth of this scenario lies above the two per cent average of high income countries. It also lies above the 2,3 per cent increase forecast for the next two years of high income countries. The 'low economic growth' scenario from the Energy Commission encompasses an increase to 11564 GWh in 2015, which is much lower than the 14770 GWh which will be generated in 2015 according to VRA.

The Low Emissions Development criteria for emissions per capita in the electricity sector can be measured according to the method described in chapter four as shown in table 5.8.

	CO_2 emissions per capita (tonnes)	CO_2 emissions per capita in the electricity sector (tonnes)	Share of CO_2 emissions in elec. sector compared to total CO_2 emissions
2008 (reality)	0,4331	0,0661[11]	15 %
2015 (criteria)	0,5857	0,0859	15 %[12]

Table 5.8: Calculation of CO_2 emissions in 2015 in the electricity sector according to LED criteria

Business as usual and criteria for the electricity sector of Ghana in 2015

Now that these measurements have been done it is possible to visualise these numbers in one graph. This is done in figure 5.7

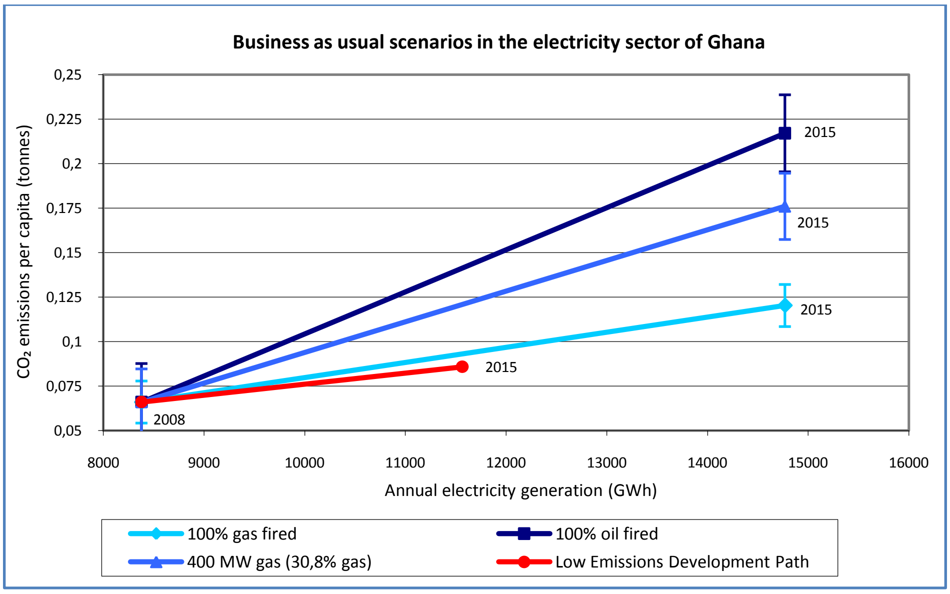


Figure 5.7: Business as usual scenarios in the electricity sector of Ghana

[11] The total electricity emissions per capita are derived from table 5.4

[12] The assumption is being made that the share of emissions of the electricity sector in 2008 will remain about the same in 2015 compared to total emissions. In this way the criteria in 2015 for the CO_2 emissions per capita in the electricity sector can be measured.

This figure shows the LED path in a business as usual scenario for a situation with 100% Light Crude Oil fired thermal plants (dark blue line), 400 MW gas fired thermal plants (medium blue line) and 100% gas fired thermal plants (light blue line). The error bars at the end of the lines show the difference between electricity generation with the expansions of the steam turbine generators (the lowest part of the error bars) and electricity generation without the expansions of the steam turbine generators (the highest part of the error bars). The red line shows the trajectory for a Low Emissions Development Path, with a minimum generation of 11564 GWh in 2015 and a maximum of 0,0859 tonnes CO_2 per capita.

These business as usual scenarios all show that the amount of GWh generated will be higher than the minimum of development, but the emissions per capita in this sector will grow higher in all scenarios. However, the difference between 100% oil fired thermal plants and 100% gas fired thermal plants is striking. There are almost twice as much carbon dioxide emissions per capita when the thermal plants are oil fired in comparison when the thermal plants are gas fired. This shows the importance to invest in this gas fired option, because it will bring the emissions per capita much closer to the criteria that have been set for the LED goal described in chapter four.

Box 5.1: Limitations to the business as scenario

There are some limitations to this kind of scenario building. First of all this scenario does not look at the emissions between 2008 and 2015, but only at these two points. This means that between these years the emissions per capita could be much higher than the lines show, because the graph assumes that the emissions per capita will grow steadily. Another limitation is that this scenario does not calculate the emission reductions in other countries because of this scenario in Ghana. This is because the gas option can reduce substantial reductions of emissions which are caused by flaring in Nigeria. Next to that Ghana wants to become an electricity exporting country (personal communication, May 2010) and therefore they could reduce emissions for countries where they export their electricity to, like Benin and Burkina Faso.

Although there are some limitations to this kind of scenario building as described in box 5.1, the tool still gives a good guideline about the effect of a business as usual scenario compared to a Low Emissions Development path. In the next chapter the possibilities to bring these blue lines of figure 6.5 down will be discussed. First there will be more focus on the electricity sector of Ghana to show how the different dimensions of the policy arrangement approach can help to comprehend this sector.

5.4. Actors in the electricity sector

The actors within the electricity sector of Ghana can be divided up into the four groups following the policy arrangement approach introduced in chapter three. These four groups are 'state', 'market', 'interests' and 'expert groups'. This paragraph will focus on these groups and fill them in for the electricity sector.

Within the group 'state' there are five different actors which play an important role in the electricity sector of Ghana. First of all there is the Ministry of Energy (MoE). This is the 'government mouthpiece' and responsible for energy policy formulation. Secondly, there is the Energy Commission. This is an Energy Policy Advisory Board and responsible for planning, licensing, technical regulation & monitoring of the energy and electricity sector. The third state actor is the Public Utility Regulatory Commission (PURC). This commission is responsible for the electricity tariff regulation and service quality standards. Fourth there is the Environment Protection Agency (EPA). This agency is the leading public body for protecting and improving the environment of Ghana and it has been

responsible for the writing of the National Appropriate Mitigation Actions (NAMAs). Last but not least there is the National Development Planning Commission (NDPC). This commission provides a national development framework and they ensure that policies and strategies that are set up do not interfere with each other. Next to that they provide the Ghana Poverty Reduction Strategy which also encompasses developments in the electricity sector of Ghana.

The next group of actors is the market. It should be noted here that a lot of organisations within the market sector are actually state owned. However, since they operate in the electricity market themselves they are classified in this thesis as market institutions. In total there are seven main actors within the electricity sector of Ghana. The first one is the Volta River Association (VRA), which is the generation utility of Ghana. A second market actor falls under the jurisdiction of the VRA and is the Northern Electricity Department (NED). This department is responsible for the distribution of electricity in the Northern part of Ghana. The Electricity Company of Ghana Limited (ECG) is responsible for distribution of the Southern part of the country, including the capital city Accra. Another company is Ghana Grid Company Limited (GRIDCO). This is the transmission utility of the electricity sector. The last three actors are independent power producers. The first one is TAQA, an international company which owns 90% of TICO. The second one is Takoradi International Company which owns the Takoradi 3 thermal plant. The last one is the Asogli Power Company, which is constructing the Sunon-Asogli Power Plant. More private investors are looking at options to step into the market, but these three are the most concrete ones so far. The main actors within this electricity sector can be mapped out to give an overview of the different roles and to show how the actors are interconnected with each other. Figure 5.8 shows this overview (Vanderpuye, 2010).

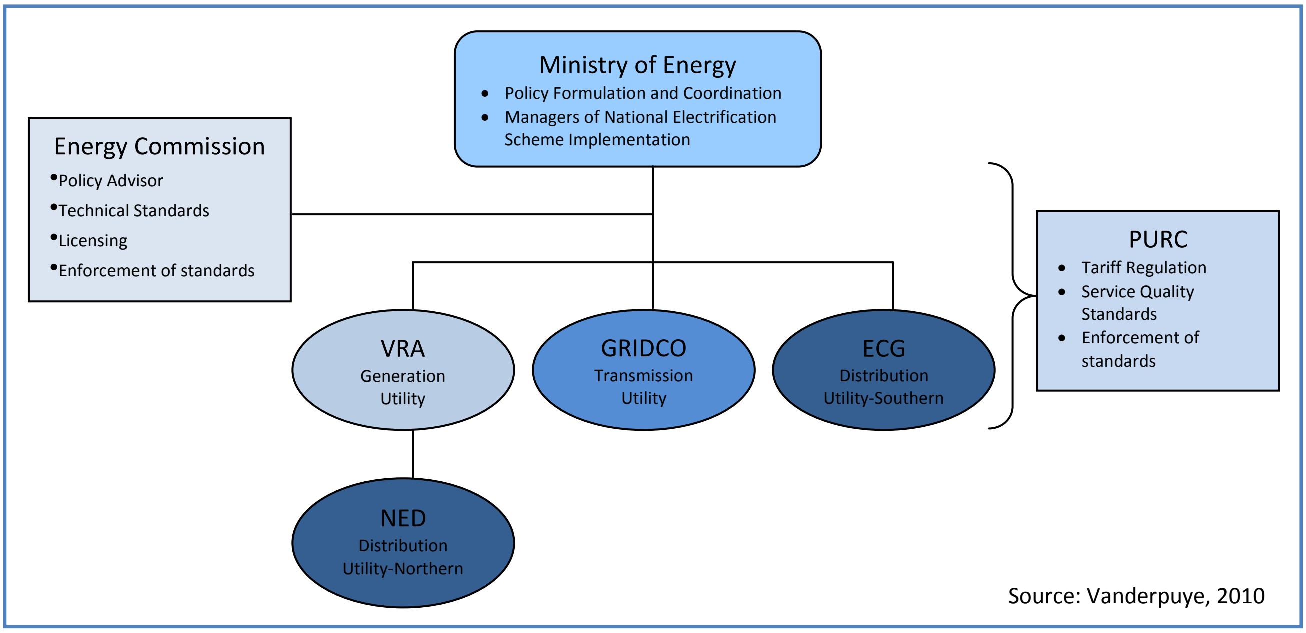


Figure 5.8: Structure of the actors in the electricity sector of Ghana

The third group of actors are the group 'interest'. Interest can be divided up into two groups. First there are the donors, which are mainly developed countries or intergovernmental organisations like the World Bank. Secondly there are also the NGOs which have interests in the electricity sector of Ghana. The most important donor within the renewable energy sector is the World Bank, which currently contributes about 10,6 million US dollars in the renewable electricity sector of Ghana in different projects. Next to that the Spanish government contributes 5 million US dollar and the Japanese government contributes 1,6 million US dollar to this sector at this moment in current

projects (personal communication, May 2010). Apart from that the European Union and its member states have also been big contributors to the so called National Electrification Programme. This program commenced in 1989 and contributed to the increase of the electrification rate of Ghana from 25% in 1989 to 67% in 2008 (Vanderpuye, 2010).

The main NGO which operates within the electricity sector of Ghana is the Energy Foundation. This NGO works together with the Ghanaian government on the promotion of energy efficiency and conservation. Another important NGO is the Kumasi Institute of Technology & Environment (KITE), which facilitates the development and implementation of energy related projects and programmes (personal communication, May 2010). Next to that there are some smaller NGOs like New Energy, which operates in the Northern Region of Ghana, and the Centre of Energy Environment and Sustainable Development (CEESD), which offers engineering assistance in energy services for local communities (ibid).

The last group of actors is the one in the 'expert system'. There are two main institutions in Ghana which conduct studies in electricity related issues. These are the Council of Scientific and Industrial Research (CSIR) and the Kwame Nkrumah University of Science and Technology (KNUST). The CSIR is the council for governmental and scientific research and one of their research topics is energy. KNUST, which is situated in Kumasi, has an energy centre which also conducts research into electricity related issues.

Taken all these actors together it is possible to map them according to the method which is described in chapter three. The allocation of the actors to the centre, the medium or the periphery has been calculated by looking at their influence in the electricity market according to the respondents of the interviews (personal communication, May 2010 (figure 5.9).

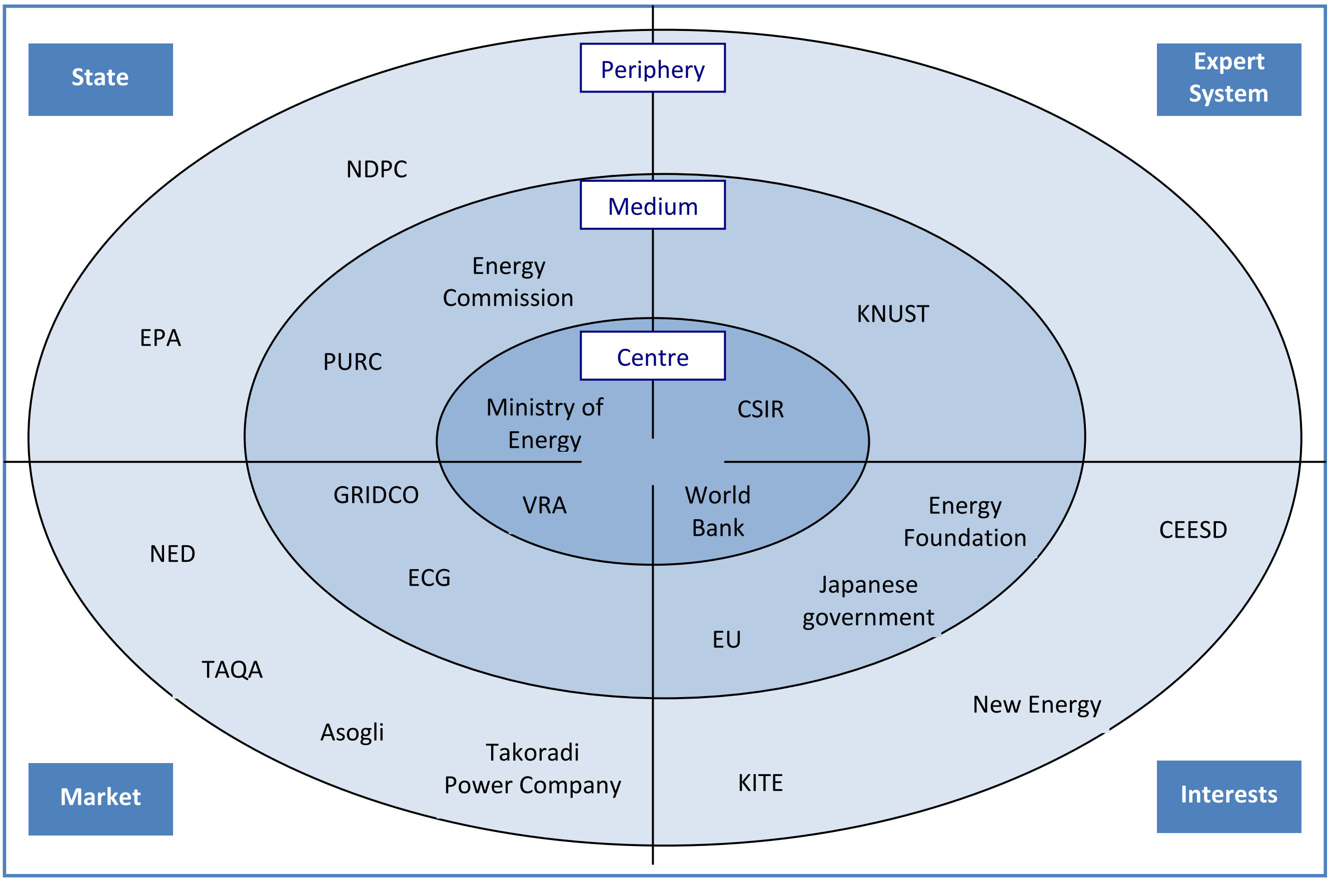


Figure 5.9: Mapping of the actors in the electricity sector of Ghana

There are three difficulties with this method. The first one is that it leaves little space for actors which do not belong to one category, like GRIDCO which is as much a state institution as a market institution, or the Japanese government, which is an interest group within the electricity market of Ghana, but will be classified as state actor in a different situation. The second difficulty is that within the group interest two very different kinds of institutions, namely the donors and the NGOs, are included in the same category. It will give more insight when these groups are separated within the interest group, as illustrated in figure 5.10.

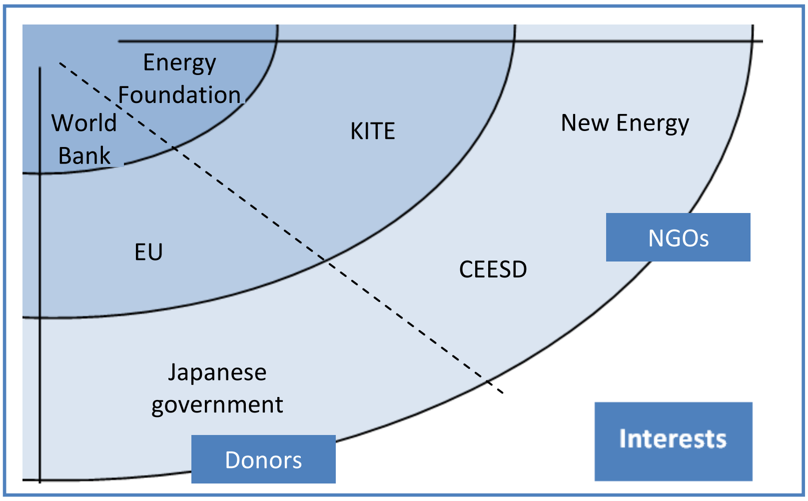


Figure 5.10: Differentiating the interest group

This shows that the allocation per group will be different when the interest group is separated. It also brings the third difficulty to the surface, which is that the allocation of the actors in the centre, medium or periphery is based on the influence within that group. However, this does not mean that an organisation which is in the medium in one group, like the Energy Commission, has as much influence on the electricity sector as an institution from the medium sector of another group, like KNUST.

5.5. Resources and power in the electricity sector

Now that all the main actors of the electricity sector of Ghana have been described this paragraph will look into the second dimension of the policy arrangement approach, which is the resources & power dimension in the electricity sector. In general three different kinds of aspects can be distinguished within this dimension of the electricity sector, 1) the power to influence electricity related policy, 2) the capacity (and knowledge) to deal with electricity related issues and 3) policy and the money you have to spend on these issues.

The actor with the most power to influence the policy of the electricity sector is the Ministry of Energy (personal communication, May 2010). This is because the two main electricity utilities, VRA and ECG, are at arm's length of the government (Aryeetey, 2005). Some respondents also saw the market, and mainly the independent power producers, as one of the actors which would get a lot of influence in the following years. This is because their presence in the electricity sector for the next couple of years will determine the electricity mix of Ghana. But as others pointed out, the investments options and the investment climate for these independent power producers would be dependent on the policy which the Ghanaian government sets out (personal communication, May 2010).

However, it is debatable in what sense the Ghanaian government has complete power and control to create its own energy policy. This has to do with the fact that a relatively big part of the total receipts consists of grants and project and programme loans from donors. None of the respondents mentioned this actor (personal communication, May 2010), although for the 2008 fiscal year these grants and loans accounted for a total of GH¢ 1475 million (around 1028 million US dollars). This is more than 20% of the total domestic revenue which consists of tax and non-tax revenue (Ministry of Finance and Economic Planning of Ghana, 2008). Especially the World Bank has been able to influence the direction of the electricity policy in the past with their resources and power. Aryeetey states that

> "In June, 1994, the Government issued a Statement of Power Sector Policy which outlined Electricity reform in Ghana. This statement of policy was driven by the indication given by the World Bank in a policy paper that it would no longer be in a position to provide funding for Electricity sector projects in developing countries" (Aryeetey, 2005, p. 34).

Also Lartey (2009) writes that the main factor for the Ghanaian government to change its policy in the electricity sector "was the pressure on the government from the international funding agencies led by the World Bank to open the industry to competition due to change in their policies towards funding of electricity projects" (Lartey, 2009, p. 3). Apart from that it is striking that the expenditure allocation overview of 2010 shows that from all the 23 ministries that Ghana has, the Ministry of Energy receives the highest amount of money from all donors combined (Ministry of Finance and Economic Planning of Ghana, 2010). During energy group meetings held at the Ministry of Energy more than half of the participants are development partners from donor agencies, while the rest consists of employees of the Ghanaian government. This shows that although the Ghanaian government has enough sovereignty to create its own policies, laws and regulation on the electricity sector, it is also influenced substantially by the interest group of donors during this process.

The other sectors have less direct influence on the electricity policy, (but nevertheless they do have their share). Within the expert knowledge group the CSIR provides the government with support and information about the electricity sector, while within the market sector the independent power producers can have substantial influence to shape the electricity sector within the next few years. The market sector has also been mentioned by respondents as the sector with the most capacity and knowledge to influence the market sector (personal communication, 2010). Their expertise to ensure reliable electricity services is a prominent factor within the electricity policy.

5.6. Rules of the game within the electricity sector

Prior to 1997 the Ghanaian government and their state-owned electricity utility organisations combined operational responsibilities with policy and regulatory issues. During the 1990's the electricity sector began to reform under the pressure of the World Bank, to overcome the limitations of the traditional set up (Aryeetey, 2005). This led to the creation of PURC and the Energy Commission which were set up by acts of Parliament (Act 538: the Public Utilities Regulatory Commission Act and Act 541: the Energy Commission Act). These were established to regulate the energy industry, including the water sector. The most important laws that have been passed since then are; (1) the Electricity Supply and Distribution Rules (technical and operational) from 2005 (L.I. 1816); (2) energy efficiency standards and labeling (non-ducted air conditioners and self-ballasted fluorescent lamps) regulations from 2005 (L.I. 1815) and (3) the electricity supply and distribution

regulations (standards of performance) from 2008 (L.I. 1935). These laws provide regulation standards for electricity utility companies and for some electrical supplies.

Next to that Ghana adopted a ‘top down’ approach in the liberalisation process by opening generation competition. This means that the door was opened for independent power producers (IPPs) to step into the electricity market (Lartey, 2009). However the response has been very slow. CMS Energy was the first to respond, but only did so in a joint venture with the government through VRA. This means that VRA is required to off-take the plant’s capacity through a twenty-five year Power Purchase Agreement (PPA) (Lartey, 2009). So far the Sunon Asogli Power is the only independent power plant (which is under construction) without state involvement. This means that so far VRA remains in a monopoly position in power generation, although the legislation has been put in place to open up the market for the IPPs.

Apart from legislation, one important document within the electricity sector is the Strategic National Energy Plan (SNEP) from 2006 – 2020. The goal of this document is “to contribute to the development of a sound energy market that would provide sufficient, viable and efficient energy services for Ghana’s economic development” (Energy Commission, 2006, p. 5). The paper provides three different expansion plans to meet supply requirements in the future. One of these options includes the usage of nuclear power to generate electricity, but it is doubtful whether this will really take place in Ghana. However, what should be noticed is that all three options include the usage of 10% renewable energy in the electricity mix of 2020. This excludes large hydro plants like the Akosombo and Kpong hydro plants. At this moment renewable energy only generates between 0,2 and 0,3% of the total electricity mix, so a lot of work has to be done to reach this 10%.

Apart from these regulations Ghana is creating legislation for renewable energy initiatives. At this moment a renewable energy bill is waiting for approval from the parliament. The framework of this bill has been created by PricewaterhouseCoopers (PwC) and commissioned by the Ministry of Energy, with the support of the World Bank. PwC provides recommendations which include a feed-in tariff for procurement of electricity from various renewable energy (RE) sources. Next to that PwC recommends that the RE law should also mandate PURC to specify the renewable energy obligation on electricity utilities (PwC, 2009b). This shows that the legislation is being put into the sector to stimulate generation of renewable energy.

The last rules of the games which directly influence the electricity sector exist on an international level. Respondents mentioned that Ghana has committed itself during the COP 15 in Copenhagen to the Copenhagen Accord. The accord states that “Non-Annex I Parties to the Convention will implement mitigation actions, including those to be submitted to the secretariat by non-Annex I Parties in the format given in Appendix II by 31 January 2010” (UNFCCC, 2009b). This has had its effect, because Ghana was obliged to hand in a list of Nationally Appropriate Mitigation Actions (NAMAs), which form an important part of a Low Emissions Development strategy as described in chapter four. This list of NAMAs which was handed in includes 55 different kinds of actions which are categorized in five sectors and ten subsectors. One of these subsectors is electricity and the 14 actions which belong to this subsector are shown in table 5.9 (Ministry of Environment, Science & Technology, 2010):

Category	Business As Usual Situation	List of Mitigation Actions	Focus
Supply	Thermal generation using light crude oil	Switch to natural gas (combined cycle)	Efficiency
	Hydro generation	Retrofit existing hydro dams	Efficiency
		Build more hydro dams	Renewable
	Off-grid / independent generation using diesel and gasoline	Improve reliability of electricity supply by improved maintenance, timely expansion and upgrading	Security
		Expand grid access to discourage the need for off-grid generation	Access
	Generation from conventional sources	Promote electricity generation from renewable energy sources to increase the share of renewable to 10-20 per cent by 2020	Renewable
Transmission	Transmission losses (5% - 6%)	Reinforce transmission systems to reduce transmission losses to 3%	Efficiency
		Balance the generations and transmission system	Efficiency
Distribution	Total distribution Losses (26%)	Standardize transformers	Efficiency / Security
		Expand and maintain distribution systems timely basis	Efficiency / Security
End-Use	Inefficient appliances and practices	Develop and enforce standards and labels for appliances	Efficiency
		Intensify public education on energy conservation	Efficiency
	Use of kerosene for lighting and cooking	Promote and support Solar PV Lighting	Renewable
		Increase rate or rural electrification	Access

Table 5.9: Nationally Appropriate Mitigation Actions Ghana - subsector electricity

The last column of table 5.9 has been added to show the focus of the different kinds of actions. Seven out of fourteen focus on energy efficiency, three on renewable energy, two on energy security and two on energy access. As stated within the document, further analysis of these actions is needed to measure the actual levels of emissions reductions as a result of the implementation of the actions. A critique on these NAMAs is that they are not interconnected with each other and with the policy of the different Ghanaian ministries (personal communication, May 2010). This means that some actions can be accomplished by single organizations, while others need the full cooperation of the whole electricity, transportation or agriculture sector.

Altogether different rules of the game play important roles in the electricity sector of Ghana. Whether it is about standardizing electrification appliances, liberalizing the market, introducing a bill to stimulate the renewable energy sector or an international agreement to set up National Appropriate Mitigation Actions, all these rules have their effect on the sector. In the next paragraph this thesis will handle the last dimension of the policy arrangement approach, namely discourses.

5.7. Discourses in the electricity sector about LED

Within the electricity sector of Ghana two main discourses can be distinguished. Both are *content related* discourses and they relate to the question whether a developing country like Ghana should invest at all in mitigation actions. The first discourse encompasses the idea that these investments should not be done. The main argument not to do it is because the contribution to anthropogenic climate change of Low Income Countries like Ghana is minimal. The 43 Low Income Countries only contribute 1,69% of the total carbon dioxide emissions. Next to that, these countries are not to blame for enhanced climate change. The developed countries are responsible for it and they also have the means to do something about it, so they should be the ones who have to invest in solutions. That is why the electricity sector in Ghana should not look at greenhouse gas emissions when electricity policy is being made, but only at the development issue, because this is much more important at this stage. It also will be much easier and more effective to tackle greenhouse gas emissions when the country has developed further, because of the larger capacity and means which will be generated in the meantime which can be used to deal with reduction of greenhouse gasses. This discourse is not the official viewpoint of the Ghanaian government, but different respondents, from both developed and developing countries, expressed these arguments.

The other discourse encompasses the idea that these investments in mitigation actions should be done, also by developing countries because these actions can provide synergy for development and mitigation. Next to that the problem of anthropogenic climate change is so severe and the potential damage to these developing countries is so serious, that any efforts to reduce emissions or potential emissions should be taken. Apart from that it might be easier to steer countries in an earlier stage towards a sustainable pathway, because a lot of investments in infrastructure and capacity building still need to be made and institutionalized. When these investments are first and foremost made in unsustainable options it can be more difficult to change the pathway of a country, because the so called 'carbon lock' will be more firm. Last but not least one important argument for this option has to do with the resource availability. Eventually countries will have to change to a sustainable energy source, because the unsustainable ones will become rare and therefore more expensive eventually. To wait for this moment is possible, but the price that will have to be paid to change to a sustainable path on a later stage could be too high, from a humane, ecological and economic point of view.

These two viewpoints show two opposite discourses which are currently applied in the electricity sector. At this moment the second viewpoint, that Ghana should invest in mitigation actions, is followed by the Ghanaian government. However, the reasons might be different from the ones which have been described above. Respondents at the government stated that as the first reason for Ghana to invest in Low Emissions Development is that they do not want to become the black sheep of the international community. They are part of a global village and have to take this into account. If for instance they would have resisted signing the Copenhagen protocol this could have resulted in negative consequences for cooperation with donors and investors. Apart from that the respondents also mentioned that the costs in the long run and the depletion of natural resources are important reasons for Ghana to invest in LED.

5.8. Crucial dimensions

This chapter first looked at the current energy and electricity mix of Ghana, then how it was formed that way and after that how it could possibly form itself in the future with business as usual scenarios. After that the focus was put on the different actors, resources and power, rules of the game and discourses which shaped and will shape the sector in the future. Taken all this information about the electricity sector together it is possible to look back at the sub-question of this chapter: *Which dimensions from the policy arrangement approach are crucial to influence the growth of prosperity and carbon emissions in the electricity sector of Ghana?*

The four main actors in the sector from the different groups are the Ministry of Energy, the World Bank, VRA and CSIR. Of these four the Ministry of Energy has the most power to shape the electricity sector. However, the influence of international institutions like the World Bank, but also the capacity and knowledge of VRA has substantial influence on the electricity policy. Apart from that the independent power producers (IPP) can also gain substantial influence on the shape of the electricity sector. The Ministry of Energy also has the most power and resources to form the sector, however again the influence of donors like the World Bank should not be underestimated. Especially because the Ministry of Energy receives most of the money from donors compared to the other ministries. Again the capacity of VRA will also be crucial in the years to come in shaping the electricity sector.

When looking at the rules of the game, the Strategic National Energy Plan gives the most direction to the electricity sector. Nevertheless other rules of the game, like the international climate negotiations also have quite some influence, because these negotiations and the Copenhagen Accord mandated Ghana to provide the National Appropriate Mitigation Actions. The Renewable Energy Bill

which is waiting to pass the Parliament will have its effect in the future. Especially the feed-in tariff which is being introduced by this bill could have substantial effects on the electricity sector of Ghana. Finally the discourse that a developed country like Ghana should also invest in mitigation actions has its influence. When this would not be the case the choices about the electricity mix of the sector (especially in the future) could be quite different.

Altogether figure 5.11 show how the most important dimensions intervene together to influence the growth of prosperity and carbon emissions in the electricity sector of Ghana.

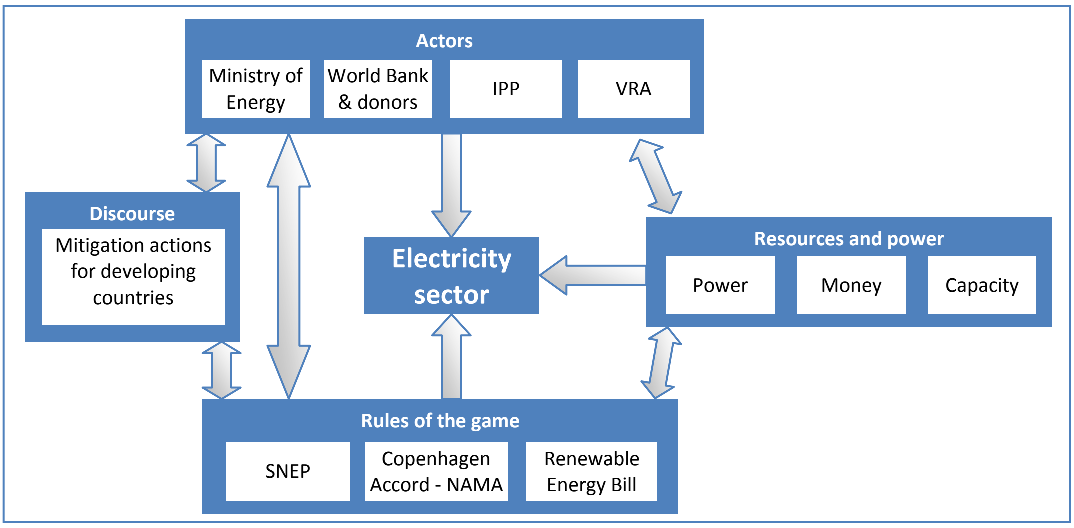


Figure 5.11: LED policy within the electricity sector of Ghana

What can be derived from this figure, which has been reshaped from the tetrahedron of chapter three, is that especially the Ministry of Energy and to a smaller extent the World Bank, VRA and IPPs will have the largest influence, because these actors control the resources and power, they make or intervene heavily with the rules of the game and they represent the dominant discourses. Next to that the figure shows how the group of actors intervene with the three other dimensions. Also the rules of the game intervene with the other three dimensions, but resources & power are not directly related with the discourse dimension. This relationship is indirect and goes via the actors and the rules of the game. Finally, the actors, the rules of the game and resources & power are directly influential on the LED aspects in the electricity sector, while the dominant discourse again influences this sector via the other dimensions.

5.9. Conclusion

The electricity sector of Ghana has been modelled to estimate a business as usual scenario and using the policy arrangement approach. This has led to the following insights concerning the possible contribution of The Netherlands to a Low Emissions Development Strategy in the electricity sector of Ghana: 1) Ghana has made a switch to a more liberal electricity market and with this it increased its share of thermal generated electricity. This is done because of the highly variable flows of the Volta River which cannot provide sufficient energy security from the Akosombo Dam and the Kpong Dam. 2) These thermal plants can be retrofitted because of the availability of gas via the West African Gas Pipeline and in the future from the newly discovered Ghanaian gas fields. This switch to natural gas to power the plants will reduce carbon dioxide emissions substantially. 3) The amount of electricity which is likely to be generated in 2015 according to the generation utility of Ghana is substantially larger than a low economic growth scenario demands. This means that Ghana will probably develop

relatively faster than developed countries within the next few years, because the economic growth in the low economic growth scenario (between two and four per cent) will most likely be equal to the amount of economic growth in developed countries. 4) The use of the policy arrangement approach showed that the World Bank is a very big actor within the electricity sector of Ghana and has a lot of influence. The Copenhagen Accord as 'rule of the game' also has substantial influence, because it provided the Ghanaian government with the incentive to create the NAMAs. 5) The discourse that developing countries like Ghana should also invest in mitigation actions indirect affects the electricity sector of Ghana.

6 Impact of a Low Emissions Development Strategy

In the previous chapter it was put apart what the electricity sector of Ghana looks like and which dimensions of the policy arrangement approach are crucial for the electricity sector and the policy which it encompasses. Now it is time to bring together the case study of the electricity sector of Ghana and the subject of this thesis, Low Emissions Development. This will be done by examining the projected effects of a LED strategy within the electricity sector of Ghana for both poverty reduction and greenhouse gas emissions.

The LED strategy which will be examined are represented by the NAMAs which have been described in the previous chapter five. As chapter four showed, NAMAs are an important part of a LED strategy. From the 14 actions which have been described in the NAMAs of Ghana the following three have been chosen to measure its effect on development and greenhouse gas emissions; (1) switch to natural gas (combined cycle); (2) promote electricity generation from renewable energy sources to increase the share of renewable energy to 10-20 per cent by 2020 and (3) develop and enforce standards and labels for appliances. These actions will be estimated to give a general impression, which means that the numbers which are used are estimations and approaches of the real situation. When these actions have been estimated and examined this chapter will provide an answer to the third sub question of this thesis: *What is the potential impact of Low Emissions Development for reductions of both poverty and carbon emissions in the electricity sector of Ghana?*

6.1. Switch to natural gas

In chapter five different scenarios of what will happen to greenhouse gas emissions when the existing thermal plants switch to the usage of natural gas have already been described. When this is not done, the emissions per capita within the electricity sector will hover around 0,2170 tonnes of CO_2. When all the thermal stations will be retrofitted and can run 100% on gas, the emissions per capita in the electricity sector will be around 0,1203 tonnes of CO_2 per capita. The last option is that the gas supply in 2015 via the West African Gas Pipeline will reach the level as that what is now agreed upon via contracts with Nigeria. This is enough gas to run 400MW of gas turbines and in this scenario the amount of CO_2 per capita in the electricity sector will be around 0,1760 tonnes.

One thing that had not been taken into account yet in those calculations were the use of own natural gas for the thermal plants. The World Bank states that the production of gas could reach around 3,4 million standard m^3 a day (in million standard cubic meters per day) (World Bank, 2009b). This could provide a substantial part of the gas necessary to power the thermal plants and therefore increase the chance that the emissions per capita will be on the low end of the scale.

What has not been described yet in the previous chapter is the effect of natural gas on the development of Ghana. The report from the World Bank (2009b) provides more information on this as well. The World Bank estimates that the arrival and extraction of gas would generate 20 to 30 thousand jobs and when productivity is doubled after 2015 another 25 to 35 thousand jobs. From an economic perspective the switch to natural gas instead of Light Crude Oil also has a lot of benefits. The World Bank (2006) estimates that within a 20 year time period the total economic benefit for Ghana for the West African Gas Pipeline (WAGP) project will be 6510 million US dollars, considered that the oil price averages 50 dollars per barrel.

However, there are some debates about these projections. According to an assessment of the Energy Commission of Ghana the West African Pipeline Project will not be economically viable for the people in Ghana. Next to that, Friends of the Earth International (FOEI) warns that the WAGP

commits Ghana to high thermal electricity costs (FOEI, 2006). The reason for this is that Ghana signed a so called tick or pay contract (personal communication, May 2010). This means that VRA will be obliged to extract a certain amount of gas from the pipeline every day. This means that they also have to pay for gas to power thermal plants (which is more expensive than the power which can be produced with hydro plants) when it is not necessary, due to low demand. Nevertheless different respondents from both the government and the utilities assured that the economic benefits to switch to natural gas were substantial.

Altogether it can be stated that the switching of fuels and using natural gas instead of light crude oil to power the thermal plants has plenty of benefits for the amount of emissions per capita. When only gas is used to power the plant, the emissions will decrease by almost a half compared to 100% light crude oil powered plants. This might even be more when the reductions of flaring in Nigeria are also taken into account. On the other side the development benefits are debatable. Some institutes consider the WAGP project, which transports the gas from Nigeria to Ghana, as something which is not economically viable and will only cause high thermal costs. However, different respondents declared that the project would be profitable and. The World Bank calculated that the average economic benefits for Ghana for the WAGP project will be an average of more than 325 million US dollars per year until 2020, partly because of savings from crude oil consumptions. In general it can therefore be concluded that switching to natural gas will substantially contribute to LED.

6.2. Promote electricity generation from renewable energy sources

The second action from the NAMAs which will be examined is the promotion of renewable energy sources in order to increase the share of renewable energy to 10 to 20 per cent in 2020. Renewable energy refers in this case to electricity from non conventional energy sources, such as solar, wind, mini-hydro and biomass. As stated before in this thesis, at this moment the share of renewable for the generation of electricity lies between 0,2 and 0,3 per cent. This means a lot of effort has to take place to reach the 10 to 20 per cent in 2020.

First let us look at the development part of this issue. PricewaterhouseCoopers (PwC) estimates that the increase to 10 % in 2020 would necessitate an additional 380 MW of renewable energy (RE) generation. This would require an investment of 446 US dollars over the period 2010 – 2020. Next to that, the aggregate power purchase costs from renewable energy sources during this period would be approximately 1 billion US dollars. However, the same report states that Ghana has a potential of 300 – 400 MW for wind, at least 95 MW from biomass and solar intensity of 4 – 6.5 KWh/m²/day (PwC, 2009b).

PwC sees the key benefit to invest in this renewable energy sources in the displacement of imports by indigenous resources. Their analysis suggests that investment in renewable energy and consequently reduction in oil imports will lead to foreign exchange saving of between 143 and 400 million US dollars in 2020, depending on the oil price scenario. However, this benefit would be limited to 41 million US dollar by 2020 if it is considered that renewable energy investments would replace sources of generation based on national gas (PwC, 2009b). Apart from that, the integration of RE generation into the existing distribution system can reduce line losses, ensure reduction in peak demand and increase overall energy efficiency. This can contribute to some extent to the reduction of losses in transmission and distribution (ibid).

This means that the introduction of renewable energy in the overall power portfolio leads to many benefits like energy security and energy access to rural areas. However it also results in additional costs for consumers. It is questioned whether the additional cost of purchases of RE

electricity can be fully passed through tariff increases. It would probably require the government to support through subsidies for the promotion of RE technologies (PwC, 2009b). The figure below shows the average RE tariff, assuming the RE energy portfolio as targeted in SNEP and the impact of purchase of electricity from RE sources on the total electricity purchase for Ghana for the period 2010 – 2020.

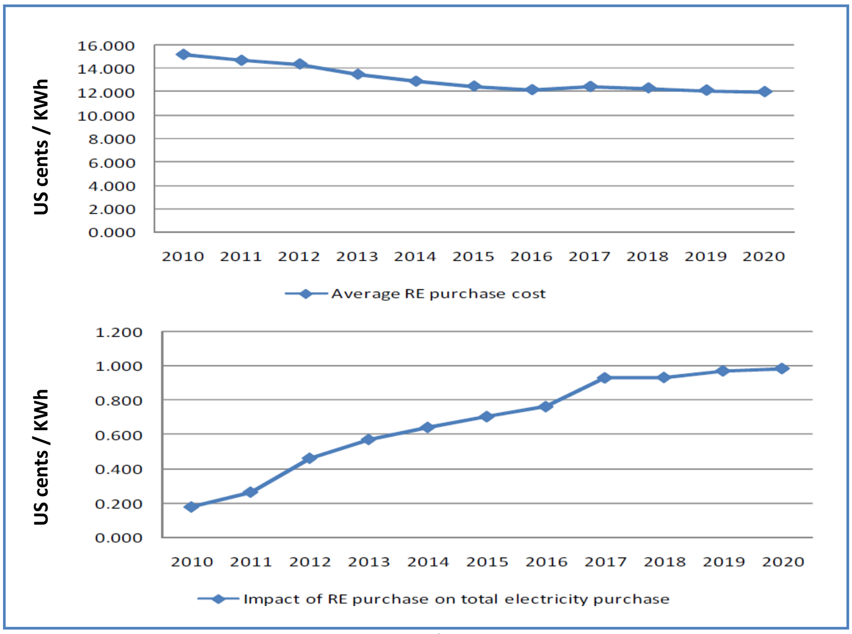


Figure 6.1: Impact of RE purchase source: PwC, 2009b

Although the impact of RE purchase on total electricity purchase is only 1 cent per kWh, the report of PwC states that “the additional support required (above the expected bulk power purchase costs of USD 318 million) would be as much as USD 643 million” (PwC, 2009b, p. 15). These high costs are one of the main challenges for the introduction of RE sources.

Nevertheless there are still some options for RE investments which can be worthwhile. When comparing the fuel costs variation to costs for RE generation from wind and solar energy (at a crude oil price of 60 US dollar per barrel) the average costs of electricity from wind is lower than that of thermal generation (simple cycle). Figure 6.2 shows this comparison, also with the average costs of solar PV generation.

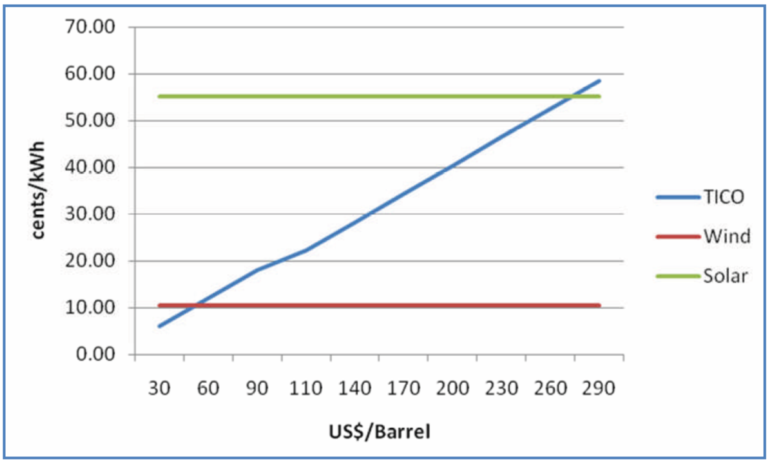


Figure 6.2: Fuel costs comparisons oil, wind and solar source: PwC, 2009c

This shows that at a crude oil price of 275 US dollars per barrel the cost of thermal generation becomes higher than the cost of generation grid connected solar (PwC, 2009c). However, the long term fuel for operating the thermal power plants is likely to be natural gas, which makes wind and solar energy relatively much more expensive, since the fuel costs in switching to natural gas could be reduced by almost one third, according to VRA (Kpodo, 2008). Next to that the downside of wind energy in Ghana this is that locations in Ghana do not provide the best opportunities for the exploitation of wind energy with average wind speeds between five and six meter per second (UNEP, 2005). However, the report of PwC (2009c) states that "with good presence of coastal areas Ghana offers a good potential for off-shore based generation" (PwC, 2009c, p. 18). Unfortunately, off shore wind generation is much more expensive than wind farms on land.

Altogether it can be stated that the investment in renewable energy sources will negatively impact the development of Ghana, since the investment costs of RE are much higher than conventional sources of energy, especially compared to natural gas. However, there is a possibility that the investment of grid infrastructure to remote rural areas is more expensive than the purchase of RE sources in these areas. In that sense it could be economically viable to invest in RE sources in these areas. However, this also encompasses some difficulties. The next chapter will get into the difficulties of the creation of these so called mini-grids.

Now that it is described how ten to twenty per cent renewable energy will affect the development of Ghana, it is also possible to look at the effects on greenhouse gas emissions. Figure 6.3 shows what will happen to the emissions per capita, when ten to twenty per cent of the conventional energy is switched to RE sources. The renewable energy sources which have been chosen and measured in this case are mini hydro and wind energy, because they are the most viable options for RE in Ghana (personal communication, May 2010). The calculations are based on 2015, which is halfway to 2020. Therefore the RE part that will be counted is five to ten per cent which is also halfway of ten to twenty per cent.

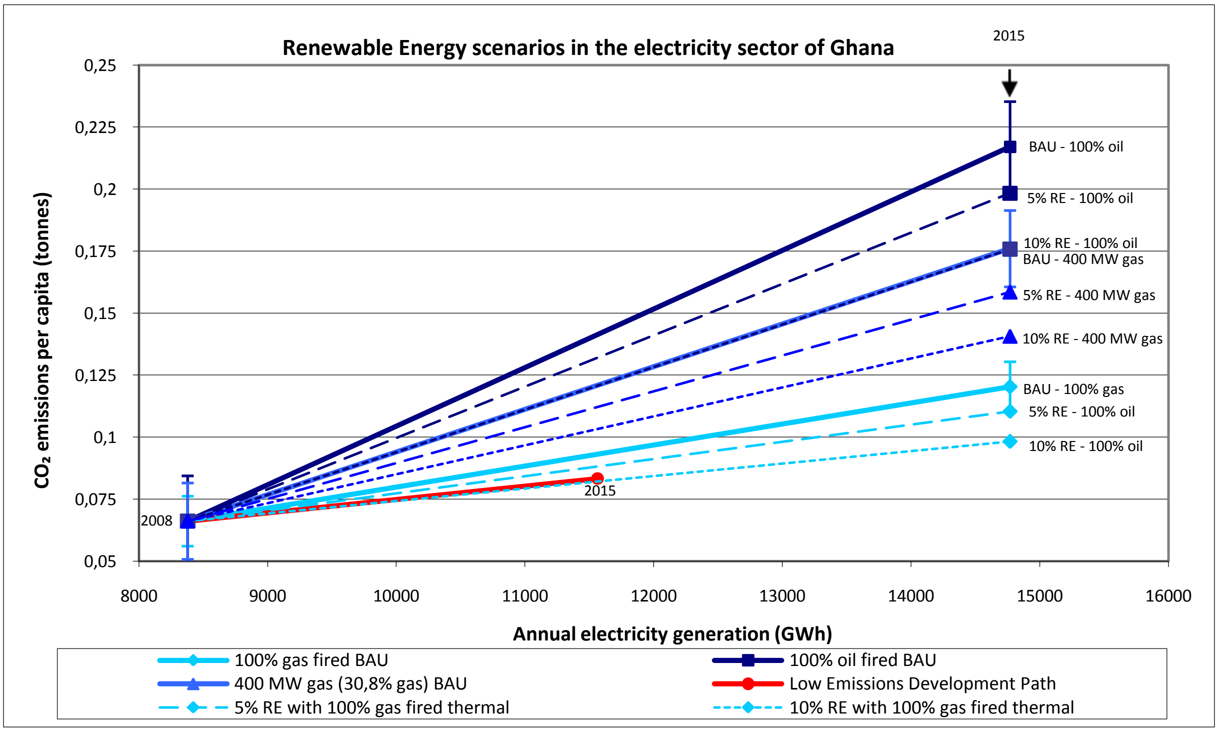


Figure 6.3: RE scenarios in the electricity sector of Ghana

A few things can be noticed from figure 6.3. First of all the amount of carbon dioxide reductions in a scenario where the thermal plants are 100% oil fired is much higher than in a situation where the thermal plants are 100% gas fired. Secondly, an increase of ten per cent renewable energy in the 100%-oil-fired-thermal scenario means the same amount of carbon dioxide reductions when 400 MW of the turbines are gas fired.

Thirdly, an investment to increase the share of renewable energy to 20% in 2020 will only slightly save more emissions than when two of the thermal plants are expanded with Heat Recovery Systems to run two steam turbines. According to the International Finance Cooperation (IFC) the investment for one of these steam turbines will be 244 million US dollars (IFC, 2004). This means that two of these steam turbines will costs almost 500 million US dollar. However, compared to the 1 billion dollars to upgrade RE share to only 10 per cent in 2020 (which will cause less emissions reductions compared to the two steam turbines), the investments in steam turbines are more viable from an economic point of view. With such investments the efficiency of the power plant with a steam turbine will increase from 33% to more than 50% (IFC, 2003).

Box 6.1: Potential of renewable energy and mini-grids

It can be stated that the increase of renewable energy will not benefit communities which already have access to the electricity grid, because the price of electricity will increase when investments in large scale RE are being made. It can however benefit communities which are not connected to the grid. Access to energy via a mini-grid can improve the standard of living substantially in certain areas, because for instance people can use lighting to study or to keep shops open for a longer period of time and use the electricity to charge mobile phones for communication.

However there are some difficulties concerning mini-grids. First of all the energy generation and energy security of these mini-grids systems is generally not too high. Secondly, most of the time mini-grids do not provide enough power and energy security for bigger companies to move towards that area (and bring their economic activities along). For these companies, access to the main grid can be one of the main conditions whether for moving towards a certain area or not. Thirdly it can be questioned whether local communities are preferring mini-grids to work with. Lartey (2009) describes how public perception to generation from renewable sources does not encourage investment in that sector. He states that "every community irrespective of the distance from the national grids wants 'Akosombo power' and it requires a strong political will to isolate a community from the national grid with an embedded generation" (Lartey, 2009, p. 7).

Taking these considerations together it can be questioned whether is it beneficial for Ghana to invest in RE. The investments in RE are relatively high when it is compared to the investments for steam turbines, while they reduce less emissions. In this scenario it might be more interesting to invest in steam turbines, because the increased efficiency of the plants will also reduce the costs of the fuel to power the plants. Next to that investments in mini-grids, which can be economically viable in certain cases, might not pay off, because of the lack in energy generation and security these grids provide. Apart from that it can be questioned if investments in mini-grids are economically viable in Ghana, because already almost 70% of the country is connected to the main grid (personal communication, May 2010) and the map of figure 6.4 also shows that there are not many areas left which are very remote from an electricity substation in Ghana.

6.3. Develop and enforce standards and labels for appliances.

The last mitigation action which will be described is the development and enforcement of standards and labels for electric appliances. There are two examples in the electricity sector of Ghana where this has happened recently. In both cases the NGO the Energy Foundation was involved. This Public Private Partnership institution has been established in 1997 and focuses on energy efficient projects. The first example is the National Compact Fluorescent Lamps Exchange Program. This project, which

was initiated by government, replaced 6 million incandescent bulbs with the more energy efficient Compact Fluorescent Lamps (CFL). This resulted in reductions of 120MW of peak demand and an annual reduction of about 150.000 ton CO_2 (which is about 2% of the annual CO_2 emissions within the energy sector of Ghana in 2006). The result of this program is that, according to data of the Energy Commission of Ghana, that at this moment only 3% of the light bulbs in Ghana are incandescent (Energy Foundation, 2010). According to Ben Hagan, the director of the Institute of Industrial Research, these energy savings realized the prevention of the construction of a 300 million US dollar power plant, while the investments for this project cost only 15 million US dollars (personal communication, May 2010).

The second example is standards and labels for refrigerators. The average energy use of a refrigerator in Ghana is 1140kWh per year, while the average in the EU is around 500kWh per year (personal communication, May 2010). A pilot project has been set up to invest in the distribution of 50.000 energy efficient refrigerators. When this project is successful it might be followed up to make sure that in a 10 year life span about half of the refrigerators in Ghana have been replaced by energy efficient ones, which could result in an average reduction of 300.000 ton CO_2 annually. A reduction of 640 KWh per year could save Ghanaians who own a fridge around 80 dollars per year. This would mean that a total of 80 million US dollar could be saved when half of the Ghanaians change to an energy efficient fridge within the next ten years.

Whether this result will be achieved is uncertain, but these two examples show that energy efficiency programs are actively being put into action by the Ghanaian government. Taken together it can be clear that these enforcement standards and labels contribute to LED in a sense that it both reduces costs and therefore increases development. At the same time it also reduces greenhouse gas emissions; these two projects alone have the potential to reduce around 450 thousand tonnes of carbon dioxide emissions. At this moment the government of Ghana is looking into the possibility to label and standardise also other electronic devices like fans. There are more than two million fans in the country, so the reductions in costs and emissions could also be severe for this case (personal communication, May 2010).

6.4. Potential impact LED strategy

Looking back at these three mitigation actions there certainly is a potential impact for a LED strategy on the electricity sector of Ghana. Therefore it is possible to answer the sub question '*what is the potential impact of a Low Emissions Development for reductions of both poverty and carbon emissions in the electricity sector of Ghana?*' On the development side the switching of fuel and the savings on electricity can reduce costs. The World Bank estimates that the West African Gas Pipeline will generate more than 325 million US dollars per year for Ghana. The savings of electricity due to energy efficient electronic devices can save the investment in a power plant of 300 million US dollar. Next to that around 90 million dollar per year can be saved by consumers due to lower electricity bills.

Apart from that there is also a possibility to receive funds from the Clean Development Mechanism and Joint Initiative from the Kyoto Protocol. PwC advised the Ghanaian government to endorse these mechanisms in their new RE bill. So far little research has been done on what this could mean for the costs of RE in Ghana. The PwC report (2009b) does not mention that it included carbon finance in their calculations about the impact of RE purchase on the electricity price[13].

[13] Further research will be needed to invest how much funds can be attracted by these mechanisms for the RE sector.

At this moment it does not seem to be the case that the increase of the share of renewable energy in the electricity mix to ten to twenty per cent will not increase development directly. The costs for this measurement, which Pricewaterhouse-Coopers measures at one billion US dollars, are substantial. The savings which can be made are limited, especially when natural gas is being replaced these savings will only account for about 41 million US dollar. Therefore from a development point of view grid connected renewable energy does not contribute much to the development of Ghana. However, there can be circumstances where renewable energy is cheaper than conventional sources of energy. This can be the case in remote rural areas where mini-grids are economically more viable, because the expensive extension of the electricity grid does not have to be paid.

When looking at the greenhouse gas reductions, the different mitigation actions can also substantially reduce emissions. Figure 6.4 shows these possible reductions.

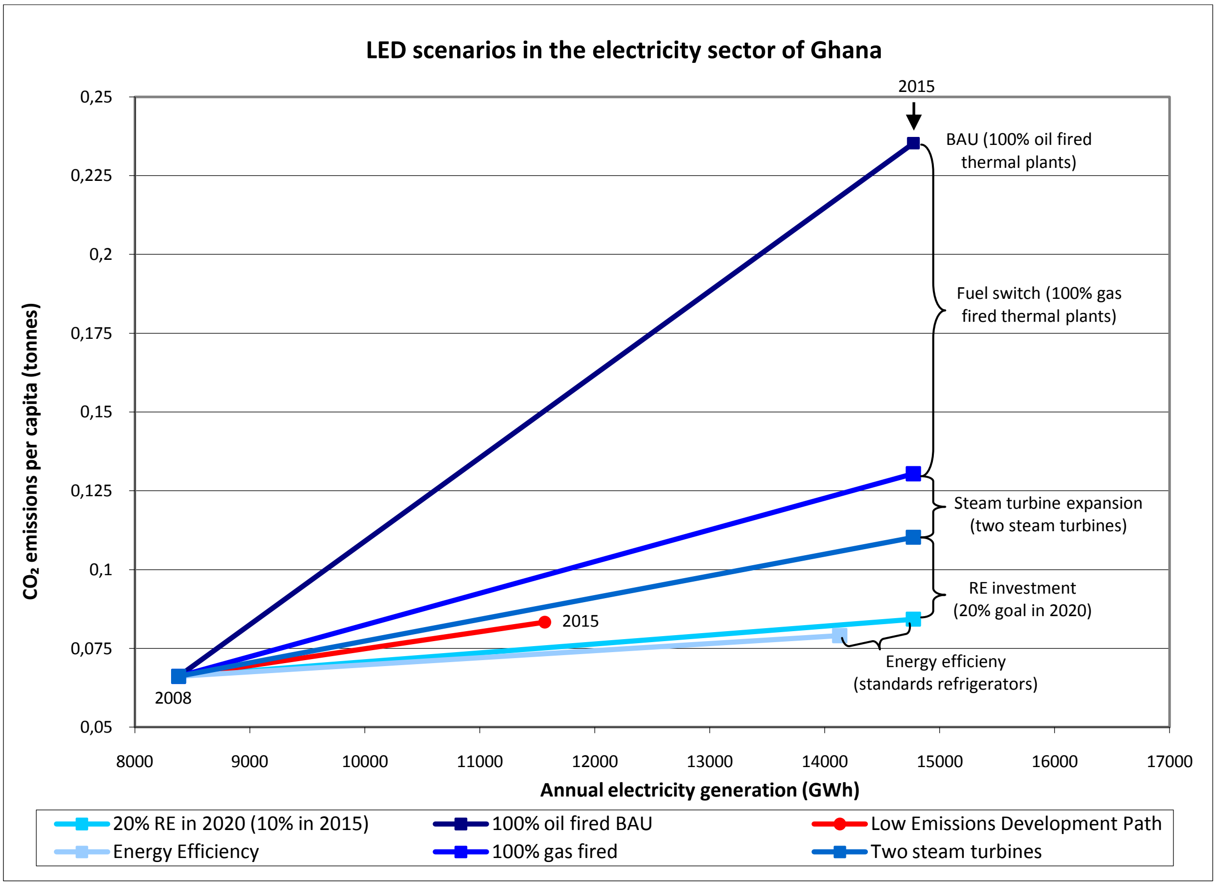


Figure 6.4: LED scenarios in the electricity sector of Ghana

In a business as usual scenario, where the thermal plants will keep being fuelled by light crude oil, the emissions will increase in 2015 to 0,24 tonne CO_2 per capita in the electricity sector. The biggest reductions can be made by switching to natural gas to fuel the thermal plants. When this is done the emissions will decrease to 0,13 tonne CO_2 per capita. The next step which can be made is to expand two thermal plants with Heat Recovery Systems and attach a steam turbine to these systems. Two of these planned expansions can reduce the emissions further to 0,11 tonne CO_2 per capita. Then the next step is to increase the usage of renewable energy sources in Ghana. When the very high goal of 20% for 2020 is taken (which means that Ghana will need to be halfway at 10% by 2015), then the

emissions per capita can further decrease to 0,084 tonne CO_2 per capita. Finally, if the pilot project of the energy efficient refrigerators becomes a success and Ghana will actually manage to replace half of all its refrigerators within the next ten years, the reductions within the first five will ensure that emissions will decrease to 0,079 tonne CO_2 per capita. Again, the red line shows the pathway towards 2050 for of a long-term stabilisation of anthropogenic carbon dioxide emissions. This means that when all the scenario's described above are followed in 2015, the emissions will reach the desired level of 0,083 tonne CO_2 in 2015 per capita. This is higher than the 0,079 tonne CO_2 per capita if all actions are carried out. Therefore these NAMAs can assure Ghana will meet the criteria for LED.

However, so far this has been a very theoretical story. The chance that all these emission reductions will really take place to the extent described above is small. The reason for this is that a lot of these changes are based on policy goals of the Ghanaian government and of the energy utility companies. However, experience in the past learned that a lot of planned changes take much more time than projected. To name a few examples; (1) the Strategic National Energy Plan (SNEP) of 2006 presumes, in all the three options it provides for expansion plans between 2006 and 2008, that the wind energy share would grow to 100 MW in 2009 and 200 MW in 2012. At this moment no wind farms have been built yet. (2) The Energy Commission of Ghana provided the supply and demand outlook for Ghana in May 2010 (Energy Commission, 2010). There it is stated that two power plants, namely Kpone 1 and Kpone 2, will be available by 2013. However, VRA does not forecast that these thermal plants will generate any electricity before 2015. In fact, when Kpone 1 was being planned the projections were that it would be finished by the end of 2008 (Modern Ghana, 2007). (3) In 2002 the Osagyefo power barge has been built in Italy and was shipped to Ghana. Eight years later this barge is still not operational and generating electricity, although VRA does expect it to be commissioned and to generate power in 2012. These examples show that a lot of energy projects are being delayed and therefore the chance that all the projects showed in figure 6.4 will be finished on time is very small.

Two of these projects are very uncertain. The first one is the expansion of the thermal power plants with steam turbines. In the case of TICO, this expansion had already been planned for a longer time, but so far delays and a change in ownership have caused the project not to be finished yet. However, in April 2010 the government of Ghana signed an agreement with TICO for the expansion, which enlarges the possibility that this expansion will be commissioned before 2015 (Ghana News Agency, 2010). However, the other expansion for Tema 1 is far away. This expansion is still waiting for approval and before it can be built Tema 1 and an additional oil/gas powered turbine will first have to be built. Therefore the chance that this expansion will be finished before 2015 is small (personal communication, May 2010).

The second project is the increasing share of RE to 20 per cent in 2020. The report of PwC (2009b) calculated that there is potential to increase the share of renewable energy to 10 per cent in 2020 with the costs of 1 billion US dollar. Therefore the chance that the share will actually reach 20 per cent in 2020 is very small. There is also no incentive to reach this level, since the NAMA states 10 to 20 per cent RE in 2020. This means that when 10,1 per cent is reached, this goal can be classified as 'achieved'. But even to reach the 10 per cent in 2020 will prove to be very challenging, if not impossible.

6.5. Conclusion

This chapter has provided an overview of what three different actions from the National Appropriate Mitigation Actions of Ghana will mean for development for emissions per capita in 2015. From a climate perspective this makes it clear that the switching from light crude oil to gas will have the biggest impact of all. It will reduce more emissions than all the three other actions combined. The introduction of two steam turbines will save relatively much emissions, especially compared with the high investments that are needed to increase the RE share, while the emission reduction with this last action is limited. Next to that this chapter showed that if a few actions which are described in the NAMAs will be followed there is a good chance that Ghana will achieve its 'low carbon criteria' within the electricity sector.

From a development perspective this chapter also shows that a higher GWh generation does not implicitly mean that a country is more developed. Energy efficiency can reduce generation amounts, but still encompass development. Apart from that the best option to invest in from a development point of view seems to be the switching of fuel and energy efficiency measures, because these can save money on the longer term. Next to that mini-grids can be economically viable in certain circumstances, but in Ghana, which is already grid connected for almost 70%, this economical viability is more limited.

Together this information answers the third sub question of this thesis: *What is the potential impact of a Low Emissions Development for reductions of both poverty and carbon emissions in the electricity sector of Ghana?* This answer is crucial for the main question of the thesis, because it shows options which can be viable to invest in for the Dutch government if they want to stimulate LED in the electricity sector of Ghana.

7 Discussions and opportunities

So far the chapters of this thesis have defined LED and developed criteria for this policy instrument. Next to that the electricity sector of Ghana has been described and the potential of LED criteria for the electricity of Ghana has been investigated. This chapter will focus discussions and look at the opportunities which LED can provide, both for developing countries as well as international assistance.

First of all this chapter will look at possible areas for support in the Ghanaian electricity sector with help from the four dimensions of the policy arrangement approach. Next to that the impact on poverty reduction with help of LED will be analyzed as well as the impact of LED on greenhouse gas emissions. Finally in the last paragraph the bottlenecks for LED policy will be looked at. Altogether the information from these paragraphs will help to answer the final sub question of this thesis; *what are the opportunities for Dutch support to the electricity sector of Ghana via a Low Emissions Development approach?*

7.1. Possible area's for support within the four different dimensions

In chapter six the four dimensions of the electricity sector of Ghana have been described and chapter six looked at the potential of different mitigation actions to ensure poverty reductions and less greenhouse gas emissions than business as usual.

First of all it is important to have a look at the different NAMAs which have been handed in by the Ghanaian government to the UNFCCC. As described earlier these NAMAs are not interconnected with each other and with the policy of the different Ghanaian ministries. This means that some actions can be accomplished by single organizations, while others need the full cooperation of the whole electricity, transportation or agriculture sector. The reason for this has to do with the limited time and capacity for the Environmental Protection Agency to formulate these NAMAs. At this moment capacity is being built and research is being done to support these NAMAs, to create interconnections with different ministries and to evaluate the potential impact of the different actions.

A number of different key persons indicated during the interviews as part of this study the possibility for Dutch support in providing capacity and knowhow to streamline these mitigation actions of Ghana. There have been difficulties for the Ghanaian government to get all the ministries working together and providing an overall framework for these mitigation actions. At this moment there are a lot of loose projects which aim to execute mitigation action. However, an overall viewpoint how and in which sector LED should be applied is missing. This is the area where the main actor of the electricity sector could be supported (personal communication, May 2010). Further research and consultations will have to provide options what the best way would be to support this option.

This thesis does not try to evaluate the 14 different actions from these NAMAs and look which one has the best potential to be supported. However, with the information from chapter six it is possible to look at the potential of the three actions described. One important aspect of support itself is that support will be required for the implementation of the action. Therefore the switch to natural gas for the thermal plants and investing in steam turbines are not on top of the list of actions needing support. This is because these actions are economically viable and can be arranged and supported largely by the market itself or are already being supported with the help of multilateral donors like the World Bank. Apart from that, the switching to fuel is already in full process since the

thermal plants are being retrofitted and the first gas has started to flow through the West African Gas Pipeline. Bearing this in mind, it makes more sense to invest in the two other areas which are renewable energy and energy efficiency. This paragraph will deal with the first one, renewable energy.

Support for renewable energy

Support to the renewable sector is important because this RE market will not create itself and a lot of effort will have to take place to reach the ten per cent (or even twenty per cent) share of renewable energy in 2020. Looked at this from a policy arrangement point of view there are two dimensions which actually do not need support. The first one is the rules of the game. This is because the new renewable energy bill is waiting to pass Parliament and the new bill, which has been created with help from PricewaterhouseCoopers, will bring a lot of opportunities for deployment of renewable energy. Of course opportunities for improvements will arise and the evaluation of the bill should be kept in mind, but this does not have the first priority. The other dimension which does not need support is the discourse about RE. Apart from the question whether it would even be possible for the Netherlands to change the viewpoint of Ghanaians about RE, since the target of ten to twenty per cent RE in 2020 is already so challenging there is no need for a different point of view on that matter.

That leaves two other dimensions open. The first one is the dimension actors. The new bill will try to draw investors in renewable energy to Ghana so they will set up their companies and generate electricity in an environmental sustainable matter. However since this is such a new market for these IPPs the Dutch government could provide support for these companies and encourage to invest in renewable energy in Ghana. When a successful example has been set up and it proves to be viable on its own there is a good chance that other IPPs will follow and therefore increase the share of renewable energy in Ghana.

The other dimension is resource and power. This encompasses most of all resources that are related to knowledge and capacity. Because of the limited experience in the renewable energy sector of Ghana, different actors could be helped a lot by technology transfer from developing countries like the Netherlands. Experts could also provide experience and expertise to set up different kinds of renewable energy sources. Especially wind energy might have some prospect in this case, because the overall potential of wind energy in Ghana is quite large with around 500 MW and the Netherlands have a lot of expertise in this field.

The downside of this is that locations in Ghana do not provide the best opportunities for the exploitation of wind energy, although the good presence of coastal areas in Ghana offers a good potential for off-shore based generation. Unfortunately, off shore wind generation is more expensive and it will prove quite a challenge to realize for Ghana. Therefore more research needs to be conducted to decide whether it is wise for the Dutch government to invest in wind energy in Ghana.

7.2. Most impact on poverty reduction via LED

It could be beneficial to invest in mini-grids, because especially in remote rural areas this could be economically more vital than the extension of the grid to these areas. However the electrification rate in Ghana is already quite high. Therefore doubts can be expressed whether mini-grids are the most effective way to stimulate both Low Carbon and Development in a country like Ghana, where already almost 70% of the people have access to the main electricity grid. This means the potential economic viability for mini-grids will be higher in other countries where rural areas are generally further isolated from the main electricity net.

Apart from that, when mini-grids are stationed in a certain area the danger exists that access to the main grid will take longer. This is because the area will be classified as 'connected', as the area already has electricity access. Since mini-grids provide less energy generation and energy security is generally lower, this can postpone more economic activities and therefore more development. Next to that the views of Ghanaians on RE and mini-grids is not always very positive. This results in the desire for remote communities to be connected to 'Akosombo power' and not to mini-grids. Altogether there are limitations to mini-grids (in Ghana) which have to be kept in mind if the Dutch government would like to support this sector.

On the other hand energy efficiency of electronic devices has a lot of potential to reduce poverty, because it will reduce costs for people that use these devices. The advantage of such efficiency is that it will affect the people directly. Energy efficiency of thermal plants is also worthwhile, but most of the time this will not improve the standard of living for a community, because the profits go to the utility companies. However, the downside of energy efficiency on electronic devices is that this kind of LED action will not reach the poorest people. This is because only those people that are already rich enough to purchase electronic devices will benefit from this measure. This means that the income inequality will increase, because only the middle class and rich people benefit from such measures.

Generally speaking renewable energy and energy efficiency can both use support from the Dutch government. However in both cases these actions have their limitations which should be examined more carefully before stepping in. In the next paragraph an impact assessment of LED on greenhouse gas emissions will be described.

7.3. Most impact on reduction of greenhouse gas emissions via LED

The action described in chapter six that has the largest impact on the reduction of greenhouse gas emissions is without any question the switch to natural gas to power the thermal plants instead of light crude oil. This action can reduce more greenhouse gasses than all the other described actions combined. However the downside on this is that this is not a sustainable option. Eventually (depending on the findings of new gas fields and the way this gas is extracted) the gas flow from both Nigeria and the Ghanaian fields will run out and then new solutions will have to be found. Nevertheless the switch to gas is a very good transition option for now which not only reduces a lot of greenhouse gasses, but will also reduce the fuel costs substantially by more than half.

The increase of the share of RE causes the second largest reductions in greenhouse gasses as shown in figure 7.4. As described however, the chance that there really will be a share of 10% renewable in Ghana by 2015 and 20 % per cent in 2020 is very small. The other action which has great potential to reduce emissions is the upgrading of a thermal plant from a single cycle to a combined cycle plant. This will cause the efficiency of the plant to increase from 30 to over 50%. The difficult part of this action is that such investments have been delayed endlessly in the past for different reasons. The good part of this action is that it is economically viable in the long run for utilities to make these investments. Support that could be given in this case is financial guarantees for investors or loans to make these investments to upgrade a single cycle plant to a combined cycle plant.

Taken all these points into consideration these paragraphs have given the answer to the sub question of this chapter. The Dutch government has different options to support LED in the electricity sector of Ghana, but most effective to improve prosperity will be to support the renewable electricity sector, and the the energy efficiency of electronic devices. The most effective measures to

reduce emissions within the electricity sector is also to invest in RE, but more effect can be achieved for less money if investments in energy efficiency of power plants are made possible. Now that these options have been described it is also a good practice to look at bottlenecks for LED.

7.4. Bottlenecks for LED within the electricity sector of Ghana

The first bottleneck about LED is the uncertainty of the *extra value* of NAMAs. The NAMAs of Ghana about the electricity sector give a good example of this bottleneck. All the actions which have been described in chapter six came directly from the NAMAs (which have been formulated in the beginning of 2010), but all these actions were already part of the current policy investment plans. For instance the decision to retrofit the thermal plants to use natural gas had already been made years ago together with the construction of the West African Gas Pipeline. The same accounts for the increasing share of renewable energy, which was already part of the SNEP out of 2006 (the only new aspect of that action is that the goal was increased from ten per cent to ten to twenty per cent).

In addition the question can be asked how *realistic* these NAMAs are. Some actions described in the NAMAs had already taken place when they were formulated, like the retrofitting of the Akosombo dam and the development of standards and labels for electronic devices. In that sense the question is what the additional value of a NAMA is, because it looks more like a summary of actions commenced or planned than a list of innovative new solutions to battle poverty and climate change together.

Another bottleneck for LED is its reference to business as usual scenarios. As just described sometimes these business as usual scenarios refer to situations from years ago. Then there is the problem that anything below a business as usual scenario could be classified as Low Emissions Development, but this is certainly not the case. When the greenhouse gas emissions of a country are 'extremely high' and it reduces these emissions to a level of 'very high' this will not mean that the actions are sustainable. Therefore it is important to have a global reference point, either out of climate deal negotiations or similar to the model described in chapter four to develop such a reference point.

The last bottleneck for LED is that it can be difficult to find *synergy between development and mitigation actions*. In the cases described in this thesis the renewable energy option can reduce emissions, but at very high costs and therefore reduce development options in other sectors. Another example is that the use of steam turbines will reduce a lot of greenhouse gas emissions, but it can be doubted whether the economic benefits will reach the customer. When mitigation actions are formulated that tackle both poverty and greenhouse gasses, like efficiency standards on electronic devices, it can turn out that the poorest part of the community will not benefit, because they have no electric devices. However there are examples which will increase both development and mitigation actions like fuel switching or energy security measures, like the creation of mini-grids which can prove to be economically viable in some parts of developing countries. Altogether these bottlenecks can prove to be quite challenging when LED in the electricity sector of Ghana wants to become a success.

8 Conclusions and recommendations

By looking at the definition and criteria for LED, and by studying the case study of the electricity sector in Ghana this thesis has provided an answer to its main question; '*what is the possible contribution of The Netherlands to a Low Emissions Development Strategy in the electricity sector of Ghana?*' These conclusions will answer that question, but also give recommendations for the Dutch government when they want to invest in Low Emissions Development. First a few points will be highlighted which are important for the Dutch government to realize when a LED strategy is being discussed.

General lessons about LED

The first most important thing to keep in mind when talking about LED is *what kind of LED we are talking about*. Does it refer to a developed country or to any developing country? This difference can be quite severe because of the different goals that they have. When a LED strategy is being created by a developed country it is essential that *all the five elements* of LED are well represented in the strategy. In that way well-considered choices can be made as to which kinds of actions need to be taken in order to achieve the best results. Next to that it is essential to realize which criteria are being followed to determine whether a strategy or a policy can be classified as LED. This also means that awareness about the short and long term vision of LED is vital when a LED strategy is being formulated.

Also important to realize is that donors still play an important role in setting a big part of the agenda for developing countries. The donors can also have an influence on the discourse which a country follows, for example by subsidising specific kinds of projects or by formulating special conditions which have to be met by the developing countries. This is also one of the reasons why the Ghanaian government believes that mitigation actions, also by developing countries, are important. Ghana wants to work together with the international community, because they recognize that they are part of a global village.

The last important aspect to realize is in what way LED strategy contributes exactly to both poverty reduction and greenhouse gas reductions at the same time. The case of Ghana gives a striking example. Increasing the share of RE on the main grid might seem an ideal target from the climate change point of view. However, due to the very high costs it can be questioned whether this is also the case from a development perspective. These points about LED are generally important to realize. However there are also some points which are important to realize specifically about the Ghanaian electricity market.

Lessons about LED within the electricity sector of Ghana

First of all the switch from light crude oil to natural gas to run thermal plants has the most positive effect on greenhouse gas emissions, compared to the other actions described in this thesis. The second biggest contribution to reduction of greenhouse gasses can be made by increasing the RE share. However the costs for this latter reduction of greenhouse gasses are very high, therefore it is questionable if this is a wise investment. Especially since investing in steam generators to upgrade two electricity plants to combined cycle plants can reduce a similar amount of emissions as a ten per cent share of RE.

Next to that it is debatable whether investing in mini-grids in Ghana can be worthwhile, because almost 70% of the people are already grid connected. This means that the relative economic vitality

of these mini-grids is less high compared to other developing countries in Sub Sahara Africa. In this light it is also good to realize that the public perception of renewable energy is not very positive. Therefore Ghana might not be the best option to invest in mini-grids. Other countries with lower electricity rates can probably provide better chances of success.

Recommendations for the Dutch government

The first recommendation is that it is prudent for the Dutch government to ensure that *all five elements of a LED strategy are present* when investing into these kinds of programmes. This means that only the formulation of NAMAs by developing countries is no solid ground for cooperation. A good LED strategy should also encompass monitoring of the process, analysis of greenhouse gas emissions with a reference to a global target and the assessment of costs, technology and capacity that has been made or will be made in the near future. Next to that there should be a clear short term and long term vision on these different elements. Only when all these elements of a LED strategy are present it is possible to make a sufficient contribution to mitigation actions in developing countries.

The second recommendation for the Dutch government is to *create a policy framework* which ensures the cooperation of all the different layers of government. This is because the coherence of LED actions across interdepartmental governmental agencies is very important to ensure that the results of one government body are not being abolished at the same time by another governmental body. This can prove quite a challenge for developing countries, but in the case of development and climate change, which touches a lot of different fields, this is very important to ensure maximum efficiency.

The third recommendation for the Dutch government is to try to *stimulate all countries in formulating LED strategies*. The main reason is that LED makes it possible to create a synergy between poverty reduction policy and greenhouse gas reduction policy. When such kind of policies are being mapped and executed, it is possible to kill two birds with one stone, because both poverty and greenhouse gasses can be reduced simultaneously. One possible way to accomplish this stimulation is to lobby within the EU and during Conference of Parties for LED to become part of a post-Kyoto protocol.

Last but not least the fourth recommendation for the Dutch government is that a LED strategy should be accomplished with assurance that mitigation actions which are being followed are *not a mere copy of old policy or actions* which have taken or are already taking place. This is the case within the electricity sector of Ghana and the NAMAs for this sector do not provide additional actions compared to a business as usual scenario. Therefore it must be assured that a LED strategy for a developing country is not just another report or standard framework in order to collect donor grants. This could be researched by the UNFCCC, because this body is also responsible for collecting and working with the NAMAs. If this would be the case then the UNFCCC should try to ensure that ambitious but realistic goals are the standard for all LED strategies.

Recommendations for further research

Apart from these policy recommendations also some recommendations can be made for further research into this topic. First of all research should focus on the additional value of the NAMAs. In the case of Ghana these NAMAs provided little additional value within the electricity sector. Therefore it would be good to look at the additional value of NAMAs and LED strategies in other countries.

Secondly the criteria which have been set out in this thesis should be further looked into. This thesis provided a basic model based on the research of the Max Planck Institute, but different factors and discussions have not been represented in this model. This should be looked into, while keeping a focus on a global sustainable target for a long term vision in order to ensure that criteria are being made which will ensure that climate change will not cross the two degrees border.

Finally within the electricity sector of Ghana further research should be done to find out to which extent the different NAMAs contribute to both development and emissions reductions. So far very little is known about this and a better understanding of the situation could increase the quality of policy decisions.

Epilogue and reflection

Looking back at this thesis different reflections can be done about the whole process. First of all I will go into the use of the policy arrangement approach to support this thesis. I am quite happy with the way this theory has supported my research. It made it easier to comprehend the electricity sector and it extended an opportunity to analyse which dimensions could be supported by the Dutch government. On the other hand I also had some difficulties with applying the theory. First of all because the theory focuses on policy, while I used the theory to describe a whole sector in a country. However this has not proven to be too much of a problem, because the different actors, rules of the game, resources and power and discourses themselves form the LED policy. Still I have the feeling I could have gotten more out of the theory if I used it more thoughtfully for describing the different dimensions in more detail. On the other hand it was not the aim of this thesis to understand the realization of LED strategy of policy itself.

When looking at the chosen research methods I am also quite pleased with the way it worked out. The different methods have helped me to realize the different part of the thesis in an efficient way. Off course here are also points of improvements to be made for a next time. One of these improvements has to do with some doubts I have about the methodology of the qualitative interviews. I made different interview guides for each individual respondent and used notes and a memo recorder to absorb the information of the conversations. However I did not transcribe these interviews, partly due to time constraints. Looking back I wonder if I could have gotten more information from the interviews if I would have transcribed them. I do not have the feeling that I missed vital information because I did not transcribe the interviews, but perhaps I would have gained more insights into certain areas if I would have taken the time to make transcriptions. However, since I do not have the feeling that I missed vital information it might have not been necessary or worthwhile the enormous effort to transcribe all the interviews.

Taken in general I am pleased with the way the thesis worked out. At some parts I might have overdone it, for instance with the creation of an Excel file which can estimate the Low Emissions Development Path of all the countries of the world. Nevertheless I feel that I covered all the areas which needed to be explained and therefore I am pleased with the end result. I hope you as reader are too.

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Annexes

Annex 1. List of interviewees

#	Name	Position	Organisation	Date of meeting
Ghanaian government				
1.	Wisdom Ahiataku-Tobogo	Head Renewable Energy Department	Ministry of Energy (MoE)	19-05-2010
2.	Solomon Adjetey	Head Power Department	Ministry of Energy (MoE)	17-05-2010
3.	Kofi Ajyarko	Head Climate Change Unit	Energy Commission	12-05-2010
4.	Oscar Amonoo-Neizer	Head Power Unit	Energy Commission	12-05-2010
5.	Daniel Tutu Benefoh	Member Climate Change Unit	Environmental Protection Agency (EPA)	17-05-2010
6.	Winfred Nelson	Principal Planning Analyst	National Development Planning Commission (NDPC)	11-05-2010
Industry				
7.	Kwaku Wiafe	Snr. Planning Engineer	Volta River Authority (VRA)	21-05-2010
8.	Mr. Julius Kwame Kpekpena	Director of Engineering	Electricity Company of Ghana (ECG)	18-05-2010
	Dr. N.K. Smart-Yeboah	Director Customer Services		
9.	Mark Baah	Manager Market Operations	Ghana Grid Company Limited (GRIDCO)	19-05-2010
10.	Sulemanu Koney	Director Analysis, Research & Finance	Ghana Chamber of Mines (GCM)	14-05-2010
11.	Moses Agyemang	Senior Economist/Admin. Manager	Private Enterprise Foundation (PEF)	18-05-2010
Donors				
12.	Sunil Mathrani	Energy Advisor	World Bank	19-05-2010
13.	Sean Doolan	Climate change & environmental governance adviser	Department for International Development (DFID) and Dutch Embassy Accra	03-05-2010
14.	Mr. Yukinari Tanaka	Officer Energy sector	Japanese International Cooperation Agency (JICA)	21-05-2010
15.	Mr. Aaron Fishman	First Secretary Environmental Office	Embassy of the United States of America Accra and United States Agency for International Development (USAID) Ghana	20-05-2010
	Mr. Matt Burton	Private Enterprise Officer		
	Mw. Jenny Jensen	Economic Officer		
NGO				
16.	Frank Atta-Owusu	Snr. Projects Manager	Kumasi Institute of Technology & Environment (KITE)	04-05-2010
17.	Mr. Prince Charles Owusu Agyemang	Projects Officer	Kumasi Institute of Technology & Environment (KITE)	21-05-2010
18.	Stephen Duodu	Programme Manager	Energy Foundation	21-05-2010
19.	Mr. Julius Cudjoe Ahiekpor	Director CEESD	Centre of Energy, Environment and Sustainable Development (CEESD)	10-05-2010
	Mr. Edward Antwi	Assistant Director		
	Mr. Edem Bensah	Project Coordinator		
20.	Amadu Mahama	Director New Energy	New Energy	06-05-2010
Science				
21.	Ebenezer Hagan	Director Institute of Industrial Research	The Council of Scientific and Industrial Research (CSIR)	11-05-2010

Table A1.1: List of interviewees

Annex 2. Example of one of the interview guides

This interview guide was used for interviewees of the Ghanaian government. None of the respondents were asked all the questions, but a selection had been made beforehand to ensure that there was enough time for the answering of the specific questions for that respondent:

Interview guide for semi structured interview in Ghana – Ghanaian Government

Thank you for taking your time to give this interview.

1. First of all, do you allow me to tape this interview?

Let me first explain the purpose of my research and the purpose of this interview. My research focuses on Low Carbon Development within the electricity sector of Ghana. I want to find out what Low Carbon Exactly means and if it can offer any additional support for reduction of both poverty and carbon dioxide emission within Ghana.

My purpose of this interview is to find out how the Ghanaian government looks at Low Carbon Development and how their energy policy influences Low Carbon Development of Ghana.

Do you have any questions before we start the interview?

Introduction

Can you first briefly tell me something about yourself and the department within the Ghanaian government where you are working for?

1. What is your position within the Ghanaian government?
   - What are your responsibilities?

2. What kind of activities is your department undertaking?
   - Can you give me some insight in the structure of your department?
   - To whom does your department report to?
   - How many people work in your department?
   - Can you tell me how much budget your department has to work with?

Low Carbon Development

3. Are you familiar with the term Low Carbon Development?

Broadly described, in my view Low Carbon Development means that a country tries to develop in a successful and sustainable manner, but I a way that within this process manmade emissions of CO_2 are to a certain level lower than the manmade emissions of CO_2 with business as usual.

4. Do you agree with this definition?
   - If not, what does LCD mean in your view?

I believe that part of a LCD strategy is National Appropriate Mitigation Actions (NAMA's). I saw on the website of the UNFCCC that on 16 February 2010 the Ghanaian government published a number of these NAMA's.

5. Was the Ministry of Energy involved in the writing and submission of this list?
    - If yes, in what way?

6. Can you tell me why the Ghanaian government has chosen to create these NAMA's?
    - Do you think that the NAMA's will generate extra investments from bilateral partners and the private sector?
        - If yes, how much do you estimate these extra investments will be over the next ten years?
    - Do you think investments in these NAMA's will generate an increase in GDP?
        - If yes, can you give an estimate how much this increase will be within the next 10 years?

The document stated that a further detailed analysis is needed, in particular in relation to the actual levels of emission reduction.

7. Do you know if this detailed analysis has been done or is being done at this moment?
    - If yes, can you tell me what the actual levels of CO_2 emissions reduction will be as a result of the implementation of these NAMA's?
        - Which of the first 14 NAMA's about electricity do you think will contribute the most to the reductions of CO_2 emissions?
    - If no, can you give me an estimate of the level of CO_2 emission reductions that will be as a result of the implementation of these NAMA's?

Another part of a LCD strategy can be feed in tariffs. I heard that there are drafts for a new energy bill which introduces these feed in tariffs.

8. Can you tell me if feed in tariffs will be part of the new energy bill?
    - What will be the implementation of these feed in tariffs?
    - Are there estimations how much extra MW renewable energy will be produced because of these feed in tariffs?
    - Are there estimations what the effect will be on the level of carbon emissions?

<u>Electricity</u>

9. What is the percentage of people that have access to electricity in Ghana?

In the Strategic National Energy Plan (SNEP) from 2006 I saw the target for accessibility to electricity is to make sure that every community with a population of 500 or more will get access to the electricity net.

- Is the policy implemented at this moment?
    - How much more communities need to be connected?
    - When all the communities of 500 and more people are connected, how much will the total electricity accessibility in Ghana be? (in %)

In the same SNEP and also mention in the NAMA's, is to ensure that 10% of the energy mix in 2020 is renewable.

10. How does the energy mix of Ghana look like right now?
    - What part of that is renewable?
    - What kind of energy mix are we talking about here? Total energy consumption or total electricity consumption?
    - What do you consider renewable? Are hydro and biomass also renewable?

At this moment most of the electricity in Ghana is being produced by the Akasombo Dam.

11. What are the investments plans for capacity expansion for Ghana?
    - What are the planned investments for new generation units and efficiency improvements?
    - Are there plans to improve the efficiency of the hydro dams?
    - Are there plans for reducing losses within the transmission and distribution system?

Actors in the electricity sector

Part of my research is to map the electricity sector of Ghana. So far I have made a list of government institutions, actors from the (electricity) industry, bilateral donors, NGO's and research institutes.

12. Which of these five different actor types has the most influence within the electricity sector to support the sector? (government, industry, donors, NGO's or research institutes?)
    - How does national policy influence the electricity sector?
        - What is the biggest change over the last 10 years within the electricity sector of Ghana which has been the result of national policy? (Can you give an example?)
    - Looking at knowledge, which actors do you think have the most knowledge within the electricity sector to make a change to a LCD economy?

These are all my questions. Do you have any questions left or do you want to clarify about what you have said in the interview?

Thank you very much for your time.

Annex 3. List of Low Emissions Development Strategies in different countries

Country	Name	Organisation	Topic of study
Argentina	UNEP Risoe Technology Needs Assessment	UNEP Risoe Centre	Low-carbon plans/TNAs/NAMAs, Background analysis
Bangladesh	UNEP Risoe Technology Needs Assessment	UNEP Risoe Centre	Low-carbon plans/TNAs/NAMAs, Background analysis
Brazil	Low-carbon Country Case Study	World Bank	Low-carbon plans/TNAs/NAMAs, Background analysis
	ESMAP Low Carbon Growth Studies Program	World Bank	Policies/deployment programs, Inventories/projections, Low-carbon plans/TNAs/NAMAs, Background analysis
	Quantifying Emission Reduction Opportunities in Emerging Economies	Ecofys	Inventories/projections, Low-carbon plans/TNAs/NAMAs, Pathways analysis, Background analysis
Cambodia	UNEP Risoe Technology Needs Assessment	UNEP Risoe Centre	Low-carbon plans/TNAs/NAMAs, Background analysis
China	ESMAP Low Carbon Growth Studies Program	World Bank	Policies/deployment programs, Low-carbon plans/TNAs/NAMAs, Background analysis
	Quantifying Emission Reduction Opportunities in Emerging Economies	Ecofys	Inventories/projections, Low-carbon plans/TNAs/NAMAs, Pathways analysis, Background analysis
Costa Rica	UNEP Risoe Cooperation	UNEP Risoe Centre	Low-carbon plans/TNAs/NAMAs, Background analysis
Cote d'Ivoire	UNEP Risoe Technology Needs Assessment	UNEP Risoe Centre	Low-carbon plans/TNAs/NAMAs, Background analysis
Europe	Roadmap 2050	European Climate Foundation	Low-carbon plans/TNAs/NAMAs, Pathways analysis
Georgia	UNEP Risoe Technology Needs Assessment	UNEP Risoe Centre	Low-carbon plans/TNAs/NAMAs, Background analysis
Ghana	Paving the Way for Low Carbon Development Strategies	Energy Research Centre of the Netherlands	Low-carbon plans/TNAs/NAMAs, Background analysis
Guatemala	UNEP Risoe Technology Needs Assessment	UNEP Risoe Centre	Low-carbon plans/TNAs/NAMAs, Background analysis
India	ESMAP Low Carbon Growth Studies Program	World Bank	Policies/deployment programs, Low-carbon plans/TNAs/NAMAs, Background analysis
Indonesia	ESMAP Low Carbon Growth Studies Program	World Bank	Policies/deployment programs, Low-carbon plans/TNAs/NAMAs, Background analysis
	UNEP Risoe Technology Needs Assessment	UNEP Risoe Centre	Low-carbon plans/TNAs/NAMAs, Background analysis
	Paving the Way for Low Carbon Development Strategies	Energy Research Centre of the Netherlands	Low-carbon plans/TNAs/NAMAs, Background analysis
Kenya	UNEP Risoe Technology Needs Assessment	UNEP Risoe Centre	Low-carbon plans/TNAs/NAMAs, Background analysis
Mali	UNEP Risoe Technology Needs Assessment	UNEP Risoe Centre	Low-carbon plans/TNAs/NAMAs, Background analysis
Mexico	ESMAP Low Carbon Growth Studies Program	World Bank	Policies/deployment programs, Low-carbon plans/TNAs/NAMAs, Background analysis
	Ecofys NAMA Activities	Ecofys	Inventories/projections, Low-carbon plans/TNAs/NAMAs, Resource assessment, Pathways analysis, Background analysis
	Project Catalyst LCGP model	Project Catalyst - Climate Works	Low-carbon plans/TNAs/NAMAs, Background analysis
	Special Program on Climate Change	Government of Mexico	Energy Efficiency, Renewable Energy, Transportation, Forestry, Agriculture
Morocco	UNEP Risoe Technology Needs Assessment	UNEP Risoe Centre	Low-carbon plans/TNAs/NAMAs, Background analysis
Peru	UNEP Risoe Technology Needs Assessment	UNEP Risoe Centre	Low-carbon plans/TNAs/NAMAs, Background analysis
Senegal	UNEP Risoe Cooperation	UNEP Risoe Centre	Low-carbon plans/TNAs/NAMAs, Background analysis
South Africa	Greenhouse Gas Emission Baselines and Reduction Potentials from Buildings	United Nations Environment Programme	Low-carbon plans/TNAs/NAMAs, Pathways analysis
	ESMAP Low Carbon Growth Studies Program	World Bank	Policies/deployment programs, Low-carbon plans/TNAs/NAMAs, Background analysis
	Quantifying Emission Reduction Opportunities in Emerging Economies	Ecofys	Inventories/projections, Low-carbon plans/TNAs/NAMAs, Pathways analysis, Background analysis
South Korea	Quantifying Emission Reduction Opportunities in Emerging Economies	Ecofys	Inventories/projections, Low-carbon plans/TNAs/NAMAs, Pathways analysis, Background analysis
Thailand	UNEP Risoe Cooperation	UNEP Risoe Centre	Low-carbon plans/TNAs/NAMAs, Background analysis
US	State Climate Action Plans	Center for Climate Strategies	Low-carbon plans/TNAs/NAMAs, Background analysis
Vietnam	UNEP Risoe Technology Needs Assessment	UNEP Risoe Centre	Low-carbon plans/TNAs/NAMAs, Background analysis

Table A4.1: Studies on Low Emissions Development Strategies in different countries

Annex 4. Measuring development: World Bank Atlas Method and HDI

There are two main institutes which provide indicators for development, which are the World Bank and the United Nations. The World Bank uses the World Bank Atlas Method and this instrument looks at GNI per capita to classify countries as high income and low income countries. The United Nations use the Human Development Index (HDI) to measure development and this index also focuses on a lot of other indicators like illiteracy rate, life expectancy, enrolment ratio in education, long-term unemployment and a gender related development index. There are quite some differences between these two instruments which will be described in this annex.

A flaw in the World Bank Atlas Method

In the World Bank Atlas Method (World Bank 2010) four different groups of countries are recognized, the High Income Countries (HIC), the Upper Middle Income Countries (UMIC), the Lower Middle Income Countries (LMIC) and the Low Income Countries (LIC). To group different countries into one of these four classifications the World Bank Atlas Method looks at the Gross National Income (GNI) per capita in 2008 of the different countries. However, like mentioned earlier in this thesis, to only use the one economic indicator of GNI per capita to determine whether a country is developed or not is quite debatable. For instance the GNI per capita indicator does not say anything about income inequality. This means that a large amount of the population of country X can live under the poverty line of 1,25 United States dollar per day but still be classified on a higher level of development, because a few habitants of country X are extremely rich. At the same time country Y can have a smaller part of the population that lives under the poverty line, but still be classified on a lower level of development than country X, because it lacks the extremely rich elite. Table A5.1 shows an example of such situation.

	Population	% of people below the poverty line	GNI of people below the poverty line	GNI of people above the poverty line	Total GNI	GNI per capita	Classification
Country X	1.000.000	60 %	$220.000.000,-	$780.000.000,-	$1.000.000.000,-	$1000,-	Lower middle income country
Country Y	1.000.000	40 %	$146.000.000,-	$754.000.000,-	$900.000.000,-	$900,-	Low income country

Table A5.1: Example of bias of the GNI-per-capita-indicator

This table illustrates the bias of the GNI-per-capita-indicator in determining the economic development of a country. 60% of the population of country X lives under the poverty line, but because of the big income inequality the country is still classified as a lower middle income country. In country Y 'only' 40% of the population lives under the poverty line, but this country is considered a low income country. This means that although country X has more inhabitants who live under the poverty line, it is still higher classified than country Y, which has 20% less inhabitants that live under the poverty line. The countries Nigeria and Senegal are a real life example of this situation. Although 64% of the Nigerians live below the poverty line of 1,25 dollar per day, it is considered a Lower Middle Income Country. In Senegal 'only' 34% of its inhabitants live below the poverty line of 1,25 dollar per day (30% less than in Nigeria), but this country is considered a Low Income Country by the World Bank Atlas Method.

This is not the only flaw in the GNI-per-capita-indicator to measure development. There is a lot of literature on the definition of development and a big part of it defines development as something more than just income. The UNDP is one of the leading institutes with this critical note and their annual Human Development Report provides the Human Development Index (HDI). In their latest

version (2009b) this index is used to classify countries into four groups of 'Very High Human Development', 'High Human Development', 'Medium Human Development' and 'Low Human Development'. These categorizations can be compared with the rankings of the World Bank Atlas Method

Comparing World Bank Atlas Method and HDI

When the rankings of the HDI are compared to the rankings of the World Bank some differences in ranking can be noticed. Table A5.2 shows these differences. There are 8 countries (4,6%) which on the HDI scale rank 30 or more places lower than on the World Bank scale. Another 8 countries (4,6%) rank 20 to 29 places lower on the HDI scale compared to the Word Bank scale. 27 countries (15,5%) rank 10 to 19 places lower. 83 countries (47,7%) rank more or less the same. Their HDI rankings differ between 10 places lower and 10 places higher compared to the ranking of the World Bank Atlas Method. 33 countries (19,0%) are ranked between 10 and 19 places higher. 12 countries (6,9%) rank 20 to 29 places higher and 3 countries (1,7%) rank 30 or more places higher than on the World Bank scale.

	Lower ranking of HDI – 30 or more places lower	Lower ranking of HDI - 20 to 29 places lower	Lower ranking of HDI - 10 to 19 places lower	Equal ranking of HDI– from 10 places lower to 10 places higher	Higher ranking of HDI – 10 to 19 places higher	Higher ranking of HDI – 20 to 29 places higher	Higher ranking of HDI – 30 or more places higher	Total
Number of Countries	8	8	27	83	33	12	3	174
Percentage	4,6 %	4,6 %	15,5 %	47,7 %	19,0 %	6,9 %	1,7 %	100,0 %

Table A5.2: Ranking HDI compared with the World Bank Atlas Method

This means that with the HDI ranking almost half of the countries receive more or less an equal score compared to the World Bank Atlas Method. However, there are still quite a number of countries which HDI ranking differ a lot from the World Bank ranking. Remarkable is the difference in the amount of countries which score a lot lower on the HDI scale (8 countries score 30 places or more places lower on the HDI scale) compared to the amount of countries which score a lot higher on the HDI scale (only 3 countries score 30 places or more places higher on the HDI scale). Seven of these countries are located in Sub Sahara Africa.

Apart from the rankings we can also look at the difference in categorization of these two methods. Table A5.3 and A5.4 show these differences. What stands out is that in table A5.3 the third classification the group of Medium Human Development countries of the HDI is much larger. In the fourth classification the group of LIC countries of the World Bank Atlas Method is much larger. When looked at the difference in categorization the groups are more or less the same. Over three quarter of the countries, 75,9 %, are categorised in the same kind of group by both methods. The reason most of the other 24,1 % of the countries are categorized in a different group is because the Medium Development Group of the HDI is much larger in comparison with the other groups.

	HIC or Very High HD	UMIC or High HD	LMIC or Medium HD	LIC or Low HD	Total
World Bank Atlas Method	43	40	48	43	**174**
Human Development Index	34	44	71	25	**174**

Table A5.3: Categorization HDI and World Bank Atlas Method

	Lower classification HDI	Equal classification HDI	Higher classification HDI	Total
Amount of countries	19	132	23	**174**
Percentage	10,9	75,9 %	13,2 %	**100 %**

Table A5.4: Difference in HDI categorization compared with the World Bank Atlas Method

Now that the ranking and classification of these two methods have been analysed, let's have a look how the development of different countries can be shown for both methods. Here this thesis will focus on nine different countries, three High Income countries, three Middle Income Countries (upper and lower middle) and three Low Income Countries. The three High Income Countries are The Netherlands, The United Kingdom and Japan. The three Middle Income Countries are China, Brazil and India. The three Low Income Countries are Ghana, Rwanda and Mozambique. The different developments of these countries via de HDI method and the WB Atlas Method can be found in figure A5.1.

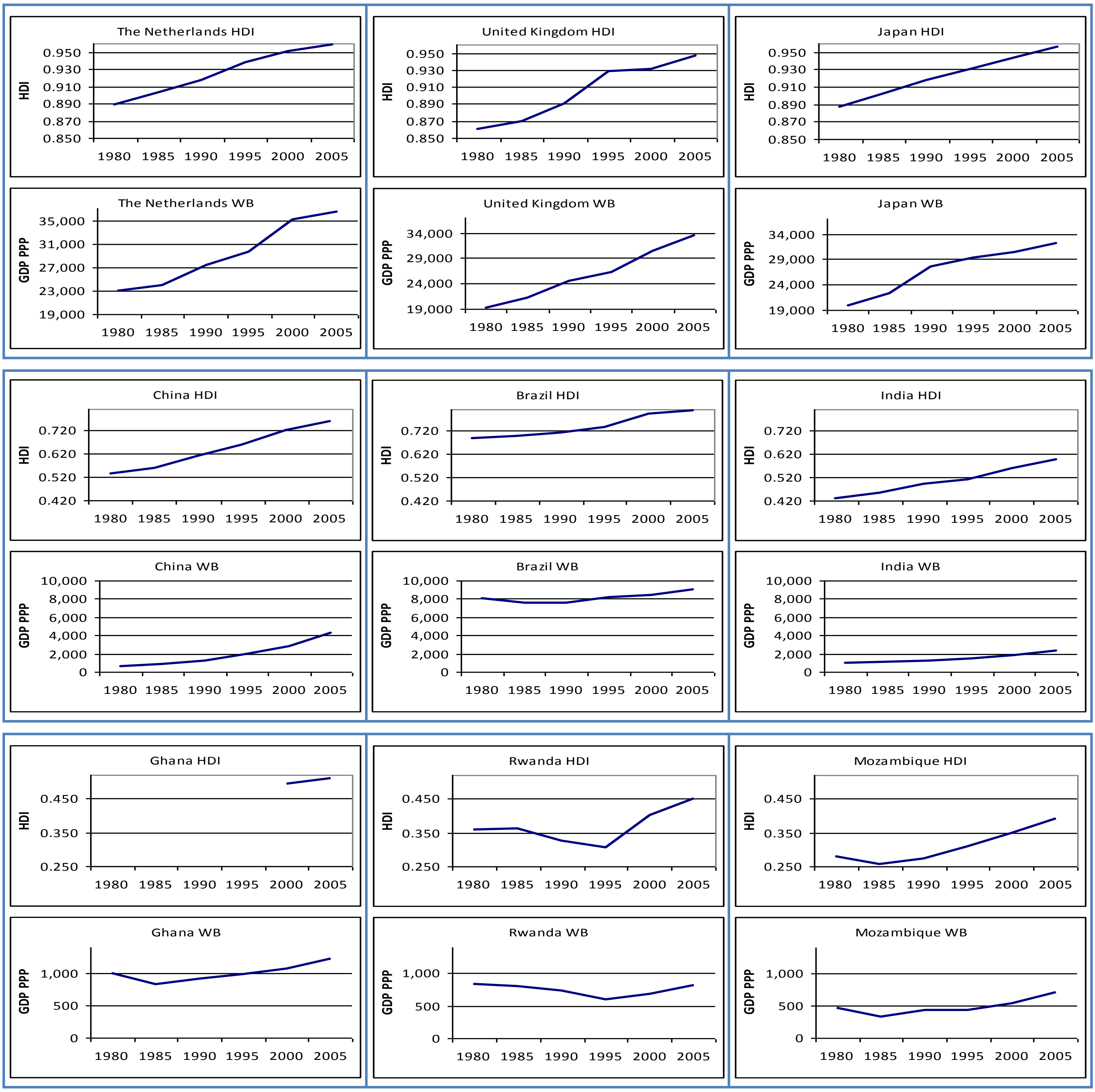


Figure A5.1: Comparison between HDI and WB methods for nine countries

What these figures show is that the trend of development is rather the same, whether the World Bank Atlas Method is used or the HDI. There is some difference in fluctuation but in general there is little difference.

Taking all the differences into consideration it can be concluded that the Human Development Index offers a more profound and precise way to measure development. When comparing it to the World Bank Atlas Method, which only looks at GDP per capita to categorize whether countries are developed or developing, the difference can be severe. However, as shown the categorization of the countries is quite similar with both methods. It is also shown that with the Word Bank Atlas Method the trend of development of different countries looks quite similar to the HDI method. Therefore this thesis will make use of the World Bank Atlas Method to determine the state of development of different countries and for determining criteria for Low Emissions Development.

Annex 5. Scenario for long-term stabilisation of greenhouse gas emissions

In the article '*Historical and future anthropogenic emission pathways derived from coupled climate–carbon cycle simulations*' Roeckner *et al*. (2010) introduce a scenario for long-term stabilization of greenhouse gas emissions. Figure A5.1 shows how this scenario looks like, both for emissions with and without climate-carbon feedback[14]. The red line in the graph represents a scenario from the Intergovernmental Panel on Climate Change (IPCC, 2007) and the green line represents the stabilization scenario.

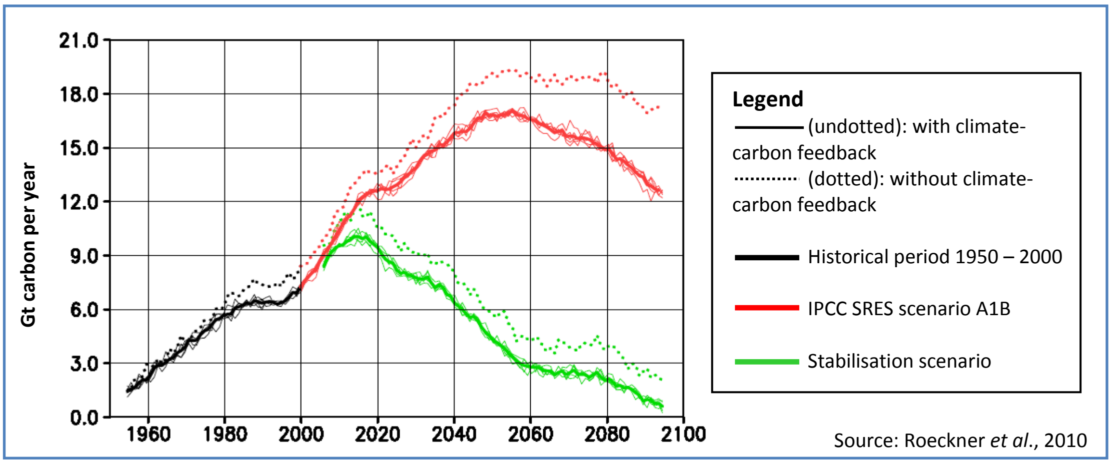


Figure A5.1: Implied CO_2 emissions 1950 to 2100 - scenario Max Planck Institute

Figure A5.2 shows what this stabilization scenario will mean for the average worldwide temperature due to anthropogenic climate change.

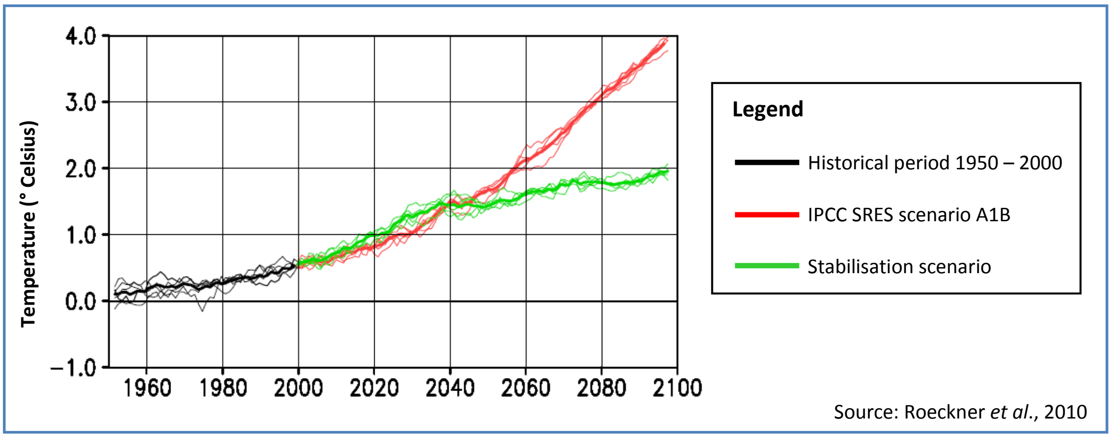


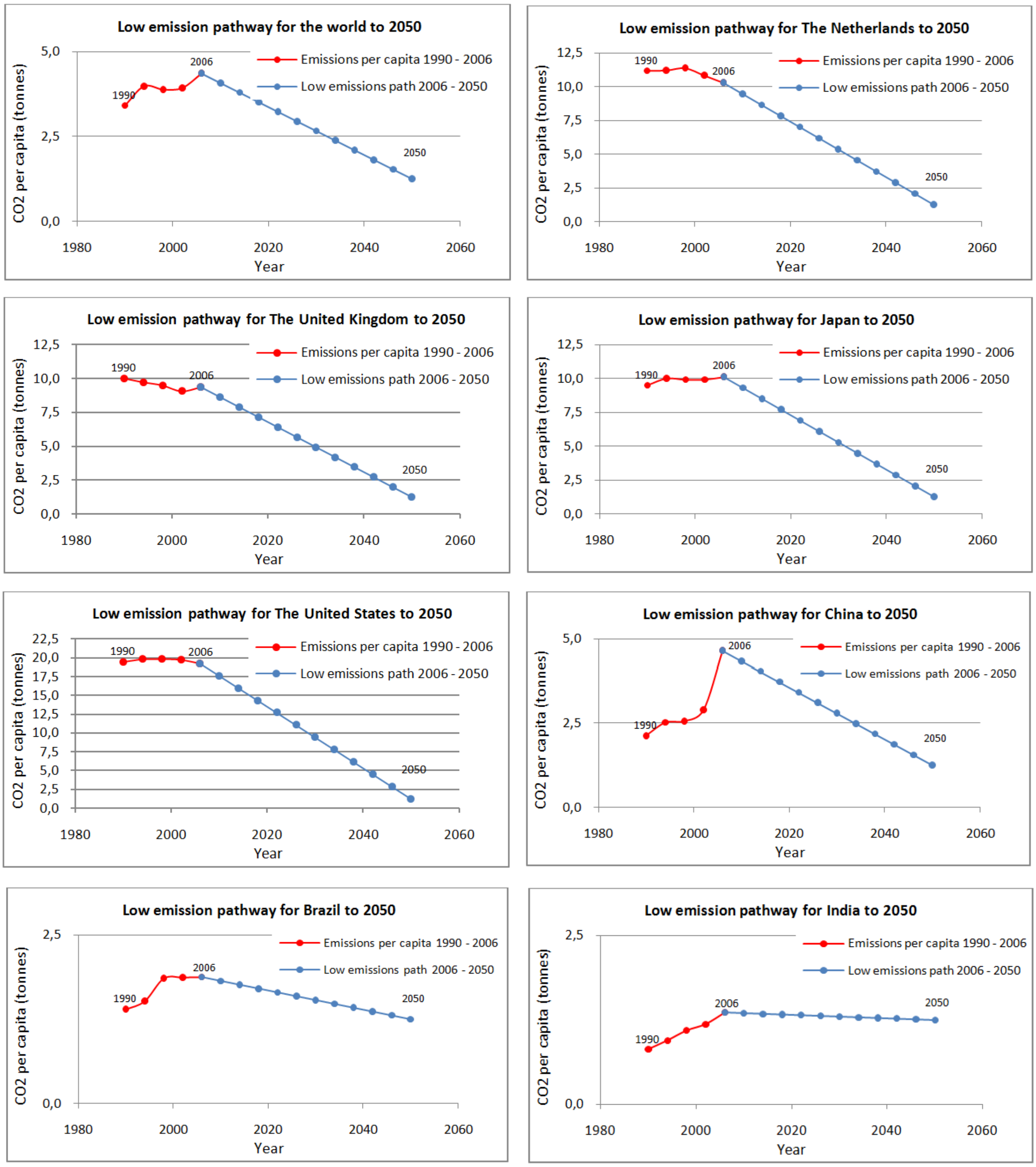
Figure A5.2: Global, annual mean surface air temperature anomalies

This shows that with the stabilisation scenario the temperature increase reach two degrees Celsius around 2100. However this target value of two degrees will probably be exceeded in an extended simulation in the twenty-second century. This result will depend crucially on climate sensitivity (Roeckner *et al*., 2010).

[14] The implied emissions are sensitive to climate change which, in coupled climate–carbon cycle models, tends to reduce the ability of both land and ocean to store anthropogenic carbon, thus the emissions have to be lower in the scenario with climate carbon feedback (Roeckner *et al*., 2010).

Annex 6. Low emissions path for different countries

The target of 2050 gives all the individual countries a goal to work to. In order to reach that goal all countries should start working in gradual steps towards this target. Figure A6.1 shows graphs what this would mean for the emissions per capita for the world and for eleven different countries.



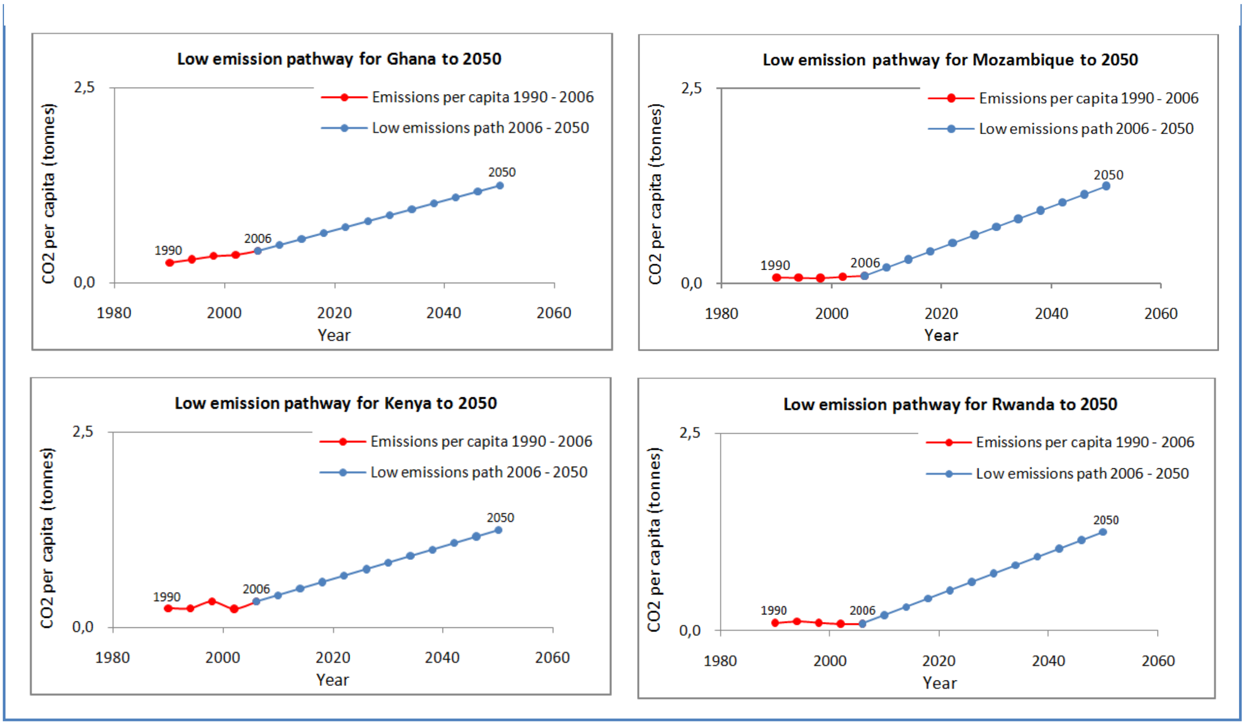


Figure A6.1: Examples of pathways in emissions per capita for several different countries

Figure A6.2 shows these countries within one graph, which makes the easy to compare the different countries. What can be noticed is that an advantage of this method is that all the developed countries will need to reduce emissions drastically compared to the developing countries. The Least Developed Countries will even be capable to increase their emissions per capita rate, because they are now emitting less than the sustainable average.

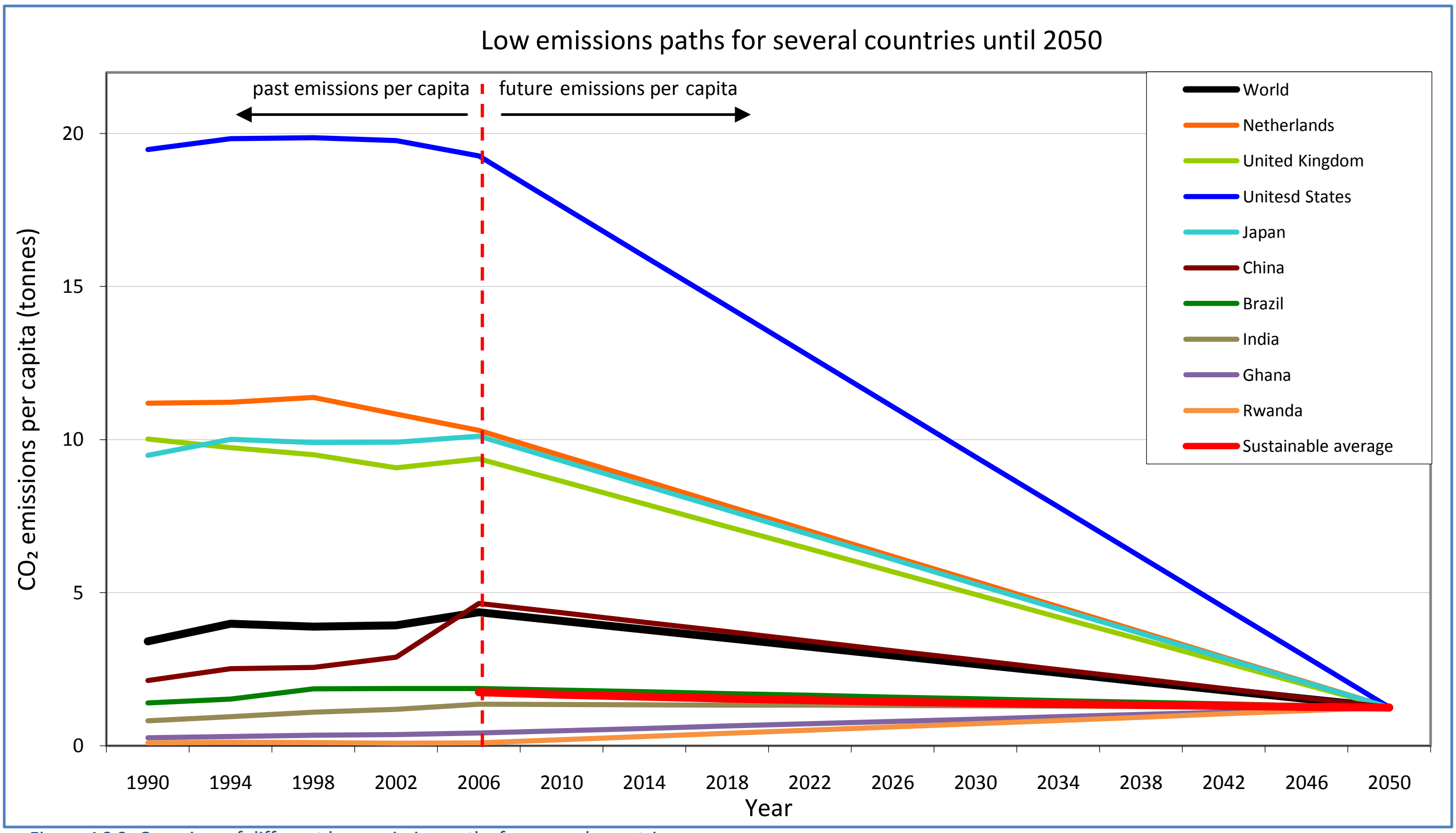


Figure A6.2: Overview of different low emission paths for several countries

Figure A6.2 clearly shows that: 1) if the scenario of Roeckner *et al*. (2010) will be followed and 2) if there is agreement that all countries will need to have equal emissions per capita in 2050, that the developed countries will have to reduce their emissions substantially in order to reach this goal in 2050. For the EU this reduction will need to be 88% in 2050 compared to 2006[15]. This falls exactly within the target of 80 to 95%. In the meantime the developing countries are allowed to increase their emissions. Rwanda for instance can emit seven times as much CO_2 per capita and still fall within the goal of 2050. However there are some limitations to this method.

Limitations

The first limitation of this method is that the pathway to a sustainable level is *too much simplified*. It assumes that countries will change their trend of emissions immediately towards a trend that will be sustainable on the long run. In reality this change of trend will happen slowly and not with a sudden change. Figure A6.3 gives a clear example of this difference for China. In the left graph the red line shows the Low Emissions Development Path for China from 1990 until 2006. The blue line shows the sustainable path for China in order to reach their sustainable goal in 2050 while their emissions per capita decrease on a equal level per year from 2006 onwards. In these graphs the GNI growth is set on 4% per year. However this low emissions path does not look very realistic. Apart from the fact that starts already in 2006, it assumes China would have to change it emissions trend very suddenly. The dark blue line in the right graph shows a more likely trend line. In this case the emissions will continue to increase for a few years and will slowly start to decrease. Therefore is seems unrealistic that countries will reduce their emissions per capita on an equal basis every four years.

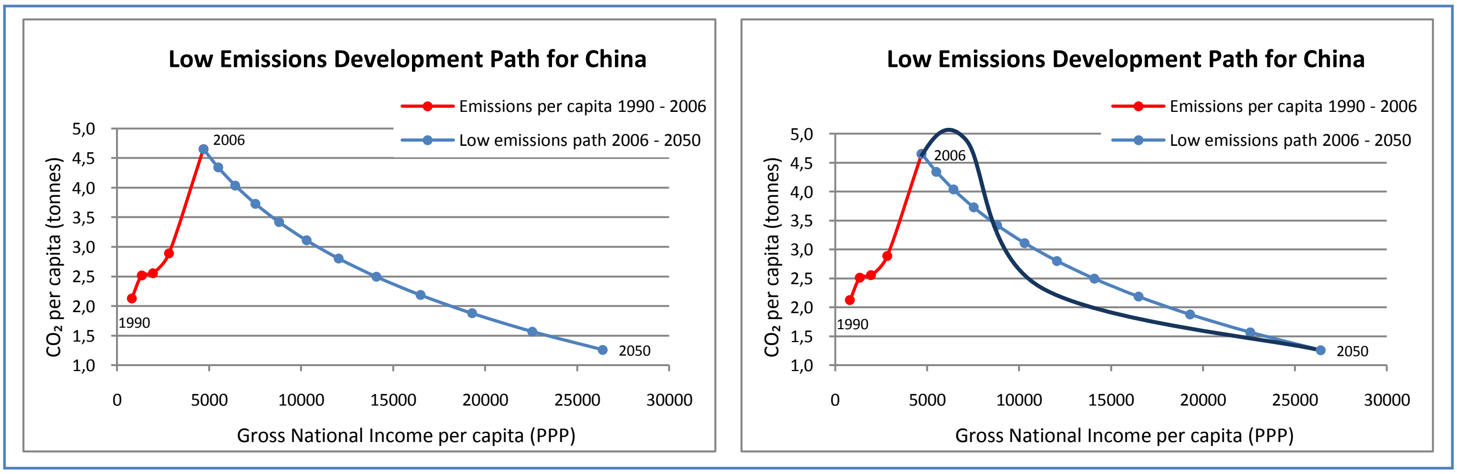


Figure A6.3: Simplification of change of trend of emissions per capita

This example of China introduces also the second limitation of this tool, which is *the virtual export of Western CO_2 emissions*. A lot of carbon dioxide which is emitted in countries like China has been the result of the manufacturing of products which are sold in developed countries. Therefore, a lot of goods that are bough in the West will contribute to the emissions per capita limit in other countries, which is virtual export of Western CO_2 emissions. This seems unfair to a certain extend. On the other hand, if a reasonable price is given to greenhouse gas emissions this problem could be solved, because in that case developing countries could ask more money for the carbon intensive products they sell and get more money for investments to reach their emissions per capita limit.

[15] The EU emitted in 2006 10,4 tonne CO_2 per capita. Reducing this to 1,24 tonne CO_2 in 2050 means a reduction of 88%.

The third limitation of this tool might be one of the toughest one. The Kyoto Protocol asked from different countries that they contributed “common, but differentiated responsibilities” (UNFCCC, 1997, p.9) to deal with climate change. With this tool this demand has been executed, because developed countries will have to reduce their emissions dramatically, while the Least Developed Countries can still increase their amount of emissions per capita. On the other hand however this does mean that *all countries will have to start to work towards a common goal immediately*. This can seem unfair, because it means that the developed countries have been able to emit a lot of greenhouse gasses in the past which caused the problem of climate change, but right now every country suddenly has to put efforts into mitigation actions. This flaw in this tool can be partly solved by the contribution of developed countries towards developing countries in these mitigation actions. This contribution can take the shape of either financial capital, knowledge transfer and technology diffusion.

Last but not least, this tool also has limitations due to its *data collection*. All the data to draw the different graphs have been collected from the website of the World Bank and the CDIAC. Although these institutes are known to provide reliable data it can still be questioned whether all the data, especially on developing countries, are always very trustworthy. This is because the capacity of developing countries to collect these data is limited. This is something which has to be kept in mind when talking about emission targets of different countries.

Although there are quite some limitations to this simplified tool it can still give an appropriate guideline for different countries in following a path towards a sustainable level of greenhouse gas emissions. It can bring the discussion to a further level and provide parameters for countries whether they are following a Low Emissions Development path or not. Therefore this tool can be helpful in defining Low Emissions Development.

Annex 7. Examples of Low Emissions Development Paths of developing countries

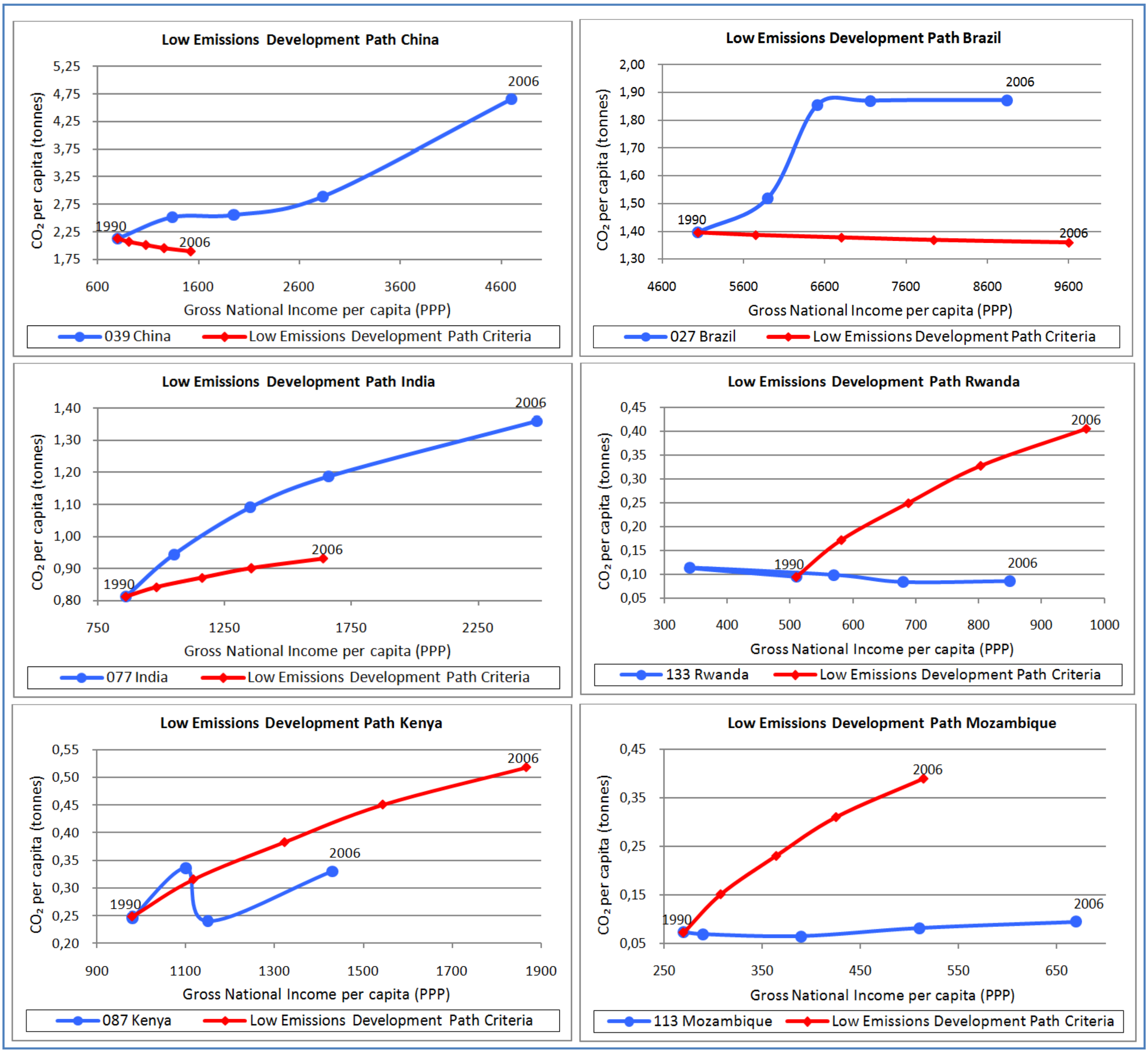


Figure A7.1: Examples of Low Emissions Developing Paths of developing countries